A Roadmap for National Action on Clinical Decision Support

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Executive Summary

Clinical decision support (CDS) provides clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care.[1] It encompasses a variety of tools and interventions such as computerized alerts and reminders, clinical guidelines, order sets, patient data reports and dashboards, documentation templates, diagnostic support, and clinical workflow tools. CDS has been effective in improving outcomes at some health care institutions and practice sites by making needed medical knowledge readily available to knowledge users. Yet at many other sites, CDS has been problematic, stalled in the planning stages, or never even attempted. As a result, relevant medical knowledge that should be brought to bear is not always available or used for many health care decisions in this country. This is an important contributor to the well-documented problems and sub-optimal performance of our health care system. Further, growing consumerism throughout U.S. society, along with efforts to shift the costs of care to patients and expand patient participation in health care decisions, are driving increasing patient and consumer demand for access to reliable medical information. Achieving desirable levels of patient safety, care quality, patient centeredness, and cost-effectiveness requires that the health system optimize its performance through consistent, systematic, and comprehensive application of available health-related knowledge – that is, through appropriate use of CDS.

This Roadmap recommends a series of activities to improve CDS capabilities and increase use of CDS throughout the United States health sector. The immediate goal of these activities is:

> to ensure that ***optimal, usable*** and ***effective*** clinical decision support is ***widely available*** to providers, patients, and individuals ***where and when they need it*** to make health care decisions.

The ultimate goal of these activities is to improve the quality of health care services and to improve health in the United States.

The Roadmap identifies three pillars for fully realizing the promise of CDS (see Figure ES-1):

- **Best Knowledge Available When Needed**: the best available clinical knowledge is well organized, accessible to all, and written, stored and transmitted in a format that makes it easy to build and deploy CDS interventions that deliver the knowledge into the decision making process
- **High Adoption and Effective Use**: CDS tools are widely implemented, extensively used, and produce significant clinical value while making financial and operational sense to their end-users and purchasers

[1] Adapted from *Improving Outcomes with Clinical Decision Support: An Implementer's Guide*, HIMSS, Osheroff et al., 2005. See Appendix B for snapshots illustrating sample CDS interventions.

- **Continuous Improvement of Knowledge and CDS Methods**: both CDS interventions and clinical knowledge undergo continuous improvement based on feedback, experience, and data that are easy to aggregate, assess, and apply**.**

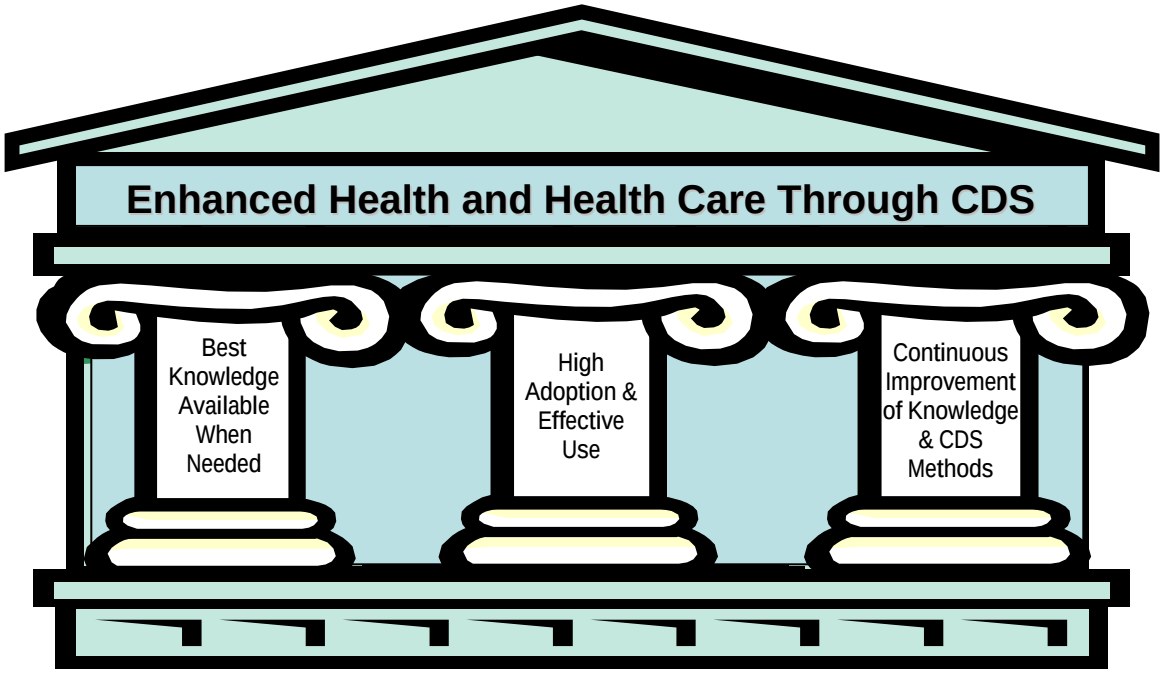

Figure ES-1. The Three Pillars for Realizing the Promise of CDS

These pillars provide the framework for organizing the many issues and tasks related to getting full benefit from CDS. Each pillar comprises two strategic objectives that correspond to the key components of next-generation CDS capabilities. As a set, these strategic objectives identify the mechanisms by which this Roadmap will help realize positive changes in the health system.

Pillar 1: Best Knowledge Available When Needed

*Strategic Objective A***: Represent clinical knowledge and CDS interventions in standardized formats** (both human and machine-interpretable), so that a variety of knowledge developers can produce this information in a way that knowledge users can readily understand, assess, and apply it.

Strategic Objective B: **Collect, organize, and distribute clinical knowledge and CDS interventions** in one or more services from which users can readily find the specific material they need and incorporate it into their own information systems and processes.

Pillar 2: High Adoption and Effective Use

Strategic Objective C: **Address policy/legal/financial barriers and create additional support and enablers** for widespread CDS adoption and deployment.

Strategic Objective D: **Improve clinical adoption and usage of CDS interventions** by helping clinical knowledge and information system producers and implementers design CDS systems that are easy to deploy and use, and by identifying and disseminating best practices for CDS deployment.

Pillar 3: Continuous Improvement of Knowledge and CDS Methods

Strategic Objective E: **Assess and refine the national experience with CDS** by systematically capturing, organizing, and examining existing deployments. Share lessons learned and use them to continually enhance implementation best practices.

Strategic Objective F: **Advance care-guiding knowledge** by fully leveraging the data available in interoperable EHRs to enhance clinical knowledge and improve health management.

There are two levels of activity presented in the Roadmap – a comprehensive work plan and a critical path for CDS activities. The Comprehensive CDS Work Plan outlines the full set of tasks needed to create a robust infrastructure for developing and delivering CDS interventions and an environment that encourages widespread successful use and continual refinement of these interventions (Section V). The Critical Path tasks represent a subset of the comprehensive work plan that can be most readily implemented and produce valuable results in the near term, and that will provide the necessary foundation for subsequent collaborations and investments needed to further build out national CDS capabilities (Section VI). This incremental approach to addressing the comprehensive work plan is considered most practical, because no public or private entity currently has the mission, resources, and strategic plan necessary to assume responsibility for the comprehensive work plan.

Key foundational elements that do not currently exist but that will be provided by the critical path tasks include: an ongoing forum for dialogue among the many CDS stakeholders, and input from those stakeholders into national initiatives for which CDS plays a critical role; consensus on the most important targets to address with CDS; and demonstration projects for successful deployment of CDS to address those targets in a manner that can be scaled nation-wide.

The Critical Path Tasks include:

1. Create a focal point for CDS in the form of a Roadmap Execution Steering Group (RESG) that will stimulate, coordinate, and guide CDS efforts outlined in this Critical Path and Roadmap. The RESG mission and structure should address the need for developing and maintaining an ongoing forum for dialogue, consensus, and action by CDS stakeholders.

2. Conduct discussions with specific organizations and initiatives with a role in promoting health care quality (e.g., American Health Information Community (AHIC), Certification Commission for Healthcare Information Technology (CCHIT), Joint Commission on Accreditation of Healthcare Organizations (JCAHO), National Quality Forum (NQF), high profile pay for performance programs) on how CDS can advance their objectives and how such support can, in turn, facilitate execution of the tasks outlined in the Roadmap.
3. Promote dissemination and application of best CDS implementation practices through development and promotion of CDS implementation guides and lessons learned from successful sites as a means of increasing use of currently available CDS interventions.
4. Develop specifications and find funding for a set of coordinated, collaborative projects aimed at demonstrating the feasibility, scalability, and value of a robust approach to CDS using a focused, top priority target. For example, pilot initiatives could include using specific, standardized CDS interventions and integration strategies, and best practice implementation approaches, to increase medication safety or effective management of high-impact clinical conditions such as diabetes or congestive heart failure. (See Straw Man Proposal).
5. Implement at least one of these scalable, outcome-enhancing CDS demonstration projects.
6. Analyze and generalize lessons learned from demonstration projects.
7. Address initial legal, regulatory, and financial issues that impact broader dissemination of CDS.
8. Identify next steps for broader CDS development and implementation as an outgrowth of the activities above.

Table ES-1: Proposed Timeline for CDS Critical Path

June-December 2006 Release Roadmap Obtain seed money for and establish RESG Create forum for CDS stakeholders and promote collaborations with and input to quality improvement and health information technology initiatives (ongoing) Promote best practices for current CDS interventions (ongoing) Obtain funding to plan scalable outcome enhancing CDS demonstration projects Establish work groups that will provide input to specifications for demonstration projects
January – December 2007 Develop specifications for demonstration projects Obtain funding for demonstration projects Clarify and address legal, financial, and policy issues (ongoing)
January – December 2008 Implement demonstration projects Analyze, generalize, and communicate results of demonstration projects (late 2008 and ongoing)
January – June 2009 Develop plan to extend CDS model to other target areas (perhaps as a new round of demonstration projects)

A proposed timeline for these tasks is presented in Table ES-1.

Sections I through IV of the Roadmap provide the context for the Comprehensive Work Plan and Critical Path. They present a description of the process used to develop this document, a vision for next generation CDS capabilities, the case for greater attention to and investment in CDS, and an analysis of the current state of CDS.

Straw Man Proposal for Demonstration of Scalable, Outcome-enhancing CDS

CDS has been shown to improve patient care processes and outcomes in a small set of institutions where it has been implemented and studied (Chaudry et al., 2006). The goal of this initiative is to demonstrate the feasibility of implementing CDS ***outside*** of benchmark organizations, in a systematic manner that can drive predictable improvements in health outcomes ***and*** be readily deployed in a variety of health care settings.

The innovations to be demonstrated and tested address the three pillars of a national approach to CDS that generates optimal outcomes (see Figure ES-1):

- providing the best available knowledge to a wide range of clinical applications and users
- improving adoption and effective use of CDS
- driving continuous improvements that yield more effective interventions and better, more useful knowledge.

The target scenario for the project applies CDS to improve safe and effective medication use and/or enhance management and outcomes for high-impact chronic diseases such as congestive heart failure or diabetes.

Specific deliverables from the pilot initiatives will include the following prototypes, models, and activities:

(1) standard, highly practical formats for representing relevant medical knowledge, developed with CDS application in mind;
(2) standard formats for general types of CDS interventions to convey this knowledge that can be readily incorporated into a variety of clinical information systems;
(3) a knowledge service that collects, organizes, and makes available validated knowledge and specific interventions related to the target conditions in standard format[2];
(4) proof of concept implementation of the above standards and services in multiple health care settings and in a variety of clinical information systems;
(5) an organized collection of best practices for deploying CDS interventions reliably and successfully to improve outcomes in the targeted areas;
(6) measurement and assessment of the usage of the above interventions, and an evaluation of their impact on patient care processes and outcomes, specifically on safety, efficiency, cost, and quality of care;
(7) documentation of issues critical to successfully generalizing the lessons learned from these pilot initiatives to broader deployment of CDS (e.g., to support other conditions, other goals, other situations) and recommendations for successful scaling of benefits.

These pilot efforts will bring together representatives from a variety of stakeholder organizations of the following classes (the specific organizations mentioned are examples for illustration purposes):

[2] A variety of models for single and multiple knowledge services have been discussed during the development of the Roadmap, and will be considered further during the execution phase.

- pioneering institutions that have demonstrated improved outcomes from CDS
- institutions that have a basic health information infrastructure in place but have not yet implemented the CDS interventions that will be the focus of this project (i.e., potential pilot implementation sites)
- clinical information system and clinical decision support suppliers (who will help provide the CDS content and infrastructure for delivering it)
- representatives from relevant agencies whose work supports CDS advancement or whose work is supported by CDS (e.g., American Health Information Community (AHIC) workgroups, Joint Commission on Accreditation of Healthcare Organizations (JCAHO), Certification Commission for Healthcare Information Technology (CCHIT), National Quality Forum (NQF), pay for performance initiatives)
- organizations that might help to fund key elements of the project (e.g., Agency for Healthcare Research and Quality (AHRQ), National Library of Medicine (NLM), Office of the National Coordinator for Health Information Technology (ONC), Centers for Medicare and Medicaid Services (CMS), other payers, private foundations)
- standards organizations that will be responsible for helping develop, maintain, and disseminate standards resulting from these pilots (e,g., HL7)
- organizations representing those who will be recipients of the CDS interventions (e.g., American Hospital Association (AHA), America's Health Insurance Plans (AHIP), American College of Physicians (ACP), American College of Surgeons (ACS))
- other key stakeholders with important contributions (e.g., Institute for Safe Medication Practices (ISMP), Institute of Medicine (IOM), chronic care model developers).

An initial core group of key stakeholders, subsequently expanded to a broader more fully representative group as project resources allow, will begin to refine the specifications of these demonstration initiatives and identify potential test sites.

The Roadmap Execution Steering Group (RESG) will oversee the planning phase of this project which will include convening key stakeholders, selecting target condition(s), refining project specifications, communicating with potential funders, and identifying potential test sites. Upon the availability of seed funding, the RESG will begin assembling key stakeholders in mid-2006, work to establish collaborations and synergies, and seek additional planning resources by late 2006. The goal is to secure project funding in 2007 and begin pilot project implementation in 2008.

I. Development and Structure of the Roadmap

In the summer of 2005, the Office of the National Coordinator for Health Information Technology (ONC) approached the American Medical Informatics Association (AMIA) with a request for a tactical plan to guide federal and private sector activities to advance CDS. AMIA established the CDS Roadmap Development Steering Committee to lead this effort.[3]

The committee developed a framework to organize discussion on the myriad tasks and issues related to CDS. This framework was considered and reviewed in detail during and following an October 2005 workshop in Washington, DC.[4] As a result of these discussions, this framework evolved into the three pillars and six strategic objectives for CDS that appear in Section II (see Table 1 in Section II).

Workshop discussions and reviews of draft versions of the Roadmap clarified the vision of next-generation CDS capabilities, and provided numerous suggestions for short-term and longer-term activities that will advance CDS. Early discussions of the American Health Information Community (AHIC) workgroups on biosurveillance, consumer empowerment, chronic care, and electronic health records (EHRs) all included reference to CDS functions for their specific breakthrough projects. These discussions also informed the Roadmap development. (See Appendix C for an overview of the AHIC workgroups and CDS related functions.) In addition, an earlier version of the Roadmap was presented to the American College of Medical Informatics; discussion by this group also validated many of the recommendations in the Roadmap when they were in formative stages.

The Roadmap Development Steering Committee identified a comprehensive set of tasks that would lead to the objective of enhancing health and health care quality through widespread use of robust CDS by consumers, patients, and health care professionals (Section V). The Steering Committee used this comprehensive plan in developing a Critical Path for CDS tasks aimed at achieving near term results with a specific focus on increasing effective use of currently available CDS interventions and demonstrating value of and potential for scalable next generation CDS capabilities (Section VI).

Given the complexity and scope of the issues associated with improving CDS in the United States, this Roadmap does not explicitly address improving CDS beyond the U.S. Other nations are also working on improving CDS as part of their national health information technology strategies (e.g., Australia, Canada, the United Kingdom). Thus, an underlying assumption of this Roadmap is that CDS efforts in the U.S. will inform and will be informed by work underway in other countries. The RESG will serve as a conduit for this cross-fertilization.

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[3] ONC's sponsorship, and the initiation of the current project, arose in part from another consensus white paper project, also sponsored by ONC and the Agency for Healthcare Research and Quality (AHRQ) and executed jointly by AMIA and the Healthcare Information and Management Systems Society (HIMSS). This initial whitepaper identified necessary enablers for realizing the potential of CDS in electronic prescribing (Teich et al., 2005).

[4] A summary of this workshop is available at http://www.amia.org/inside/initiatives/cds/. A graphic illustrator captured the content of the workshop presentations and discussions in a visual format. These images are also available at http://www.amia.org/inside/initiatives/cds/.

The remainder of this document provides material to support the Comprehensive Work Plan and Critical Path. Section II presents a discussion of the CDS destination expressed in terms of a future scenario, an overview of the information flow that is envisioned as supporting next generation CDS capabilities, and a framework for organizing the myriad issues and tasks that relate to CDS development. Section III presents the case for greater attention to and investment in CDS and Section IV describes the current state of CDS. Several appendices supplement this Roadmap with important background information including definitions of key terms used in this report, examples of CDS interventions, a description of the AHIC workgroups and potential CDS implications of each, a preliminary list of CDS-related standards, pointers to federal health information technology (HIT) programs, and a glossary of acronyms used in this report.

II. The CDS Destination

The goal of CDS is to provide the right information, to the right person, in the right format, through the right channel, at the right point in workflow to improve health and health care decisions and outcomes. For example, CDS interventions can detect potential medical errors, suggest optimal clinical strategies, organize the details of a plan of care, help gather and present data needed to execute this plan, and ensure that the best clinical knowledge and recommendations are utilized to improve health management decisions.

The environments where these capabilities could be applied are broad and encompass the full range of settings where health and health care decisions are made. These include but are not limited to, acute and chronic inpatient care facilities, the wide variety of ambulatory care settings, and even individuals' homes and other sites of daily activities. When deployed properly, CDS should involve input from and be well accepted by end-users, and should support rather than detract from their workflow. Likewise, CDS should make business sense for, and be implemented easily by, those who provide it, implement it, and use it. Ultimately, CDS will reduce adverse events, improve health maintenance and chronic disease management, improve efficiency of health care service, and reduce costs (Garg et al, 2005, Chaudhry, 2006).

A Future Scenario

The following scenario illustrates some of the ways that CDS could be used to enhance health and health care, and some of the features of a better national approach to CDS.

<u>The Patient and Clinician Perspective</u>

> DS, like many 52-year old mothers, is very vigilant about her health and the health of her family members. On a recent trip to her doctor's office, she is given a pass key to log in to her new personal health record (PHR). Both DS and her primary care physician think that it will be a good way to remember all of her medicines, track her slightly elevated cholesterol and read up on her husband's diabetes. Upon logging in for the first time, she notices something else. In the upper corner of the screen there is a section entitled "health maintenance." Clicking on this, she sees a message that the system has recommended that she get a mammogram and that her physician endorses this recommendation. DS thinks she has recently had one and is not sure she needs it. She clicks on the message and it changes to a view of all of her mammograms over the past 5 years. It appears the system is correct, she does indeed need a mammogram. By clicking on the message for the new mammogram she is able to send an electronic message to the radiology department at her local hospital and confirm an appointment for her mammogram next week.
>
> DS is able to get directions to the testing center and an update on new methods of diagnosing breast cancer directly from her health record web site. She is

particularly impressed with a short video that shows a world-renowned breast cancer specialist discussing the importance of mammogram and the overall great outcomes for patients with early stage disease. Armed with this information she feels much more a part of her health care experience and she arrives right on time for her mammogram appointment.

Meanwhile back at her office, DS' primary care provider, Doctor Jones is reviewing results in her electronic medical record system. She gets a quick note from the PHR indicating that DS has accepted a recommendation to get a mammogram and scheduled the test. A week later, Doctor Jones gets a note in the electronic health record (EHR) from radiology indicating that DS' study has come back positive. She is able to click on the message and review the latest treatment guidelines and prognosis information for breast cancer and prepare herself for the difficult phone call with DS. During the call, DS is obviously shaken, but Doctor Jones is able to convey calm competence and refer to outcome statistics for current treatment to help allay DS' exaggerated fears. Doctor Jones schedules DS for a needle localization biopsy and two weeks later, she is reviewing the results on the phone with a surgeon.

DS has cancer, but it is early stage and the prognosis should be very good. Doctor Jones has another difficult phone call with DS, but DS is grateful that the cancer has been diagnosed early and that she stands a very good chance of cure. Doctor Jones suggests that video recordings of patients with a similar diagnosis that can be accessed through the PHR might be helpful for DS. At the end of the phone call, DS has an appointment with an oncologist and scheduling information has been conveyed over the phone and sent to her PHR.

Prior to her visit with the oncologist, DS logs in to her PHR and fills out several forms with personal questions about her treatment. She is pleased to see that she is being asked sensitively about her religious beliefs and practices including her approach to blood products and her desire to seek aggressive treatments for her cancer should that be necessary. She submits all of the responses and arrives at the oncologist's office prepared for the discussion that will ensue. She has already read on the PHR about some of the treatments that she will discuss with the oncologist and the visit goes very well. The oncologist and DS decide on a treatment plan that involves radiation, chemotherapy, and surgery. It is an aggressive strategy, but the oncologist explains that this is in part due to a risky genetic profile uncovered in the many blood tests that DS has had so far. He is able to pull up the genetic profile via the EHR in the office, display it and show DS how her risk changes based on the profile. Given the fact that DS has expressed a desire to be very aggressive about her treatment in the electronic forms, the oncologist is able to further support this approach. He even recommends that DS' three sisters have genetic screening and more frequent mammograms. Since two of them are already signed up for the PHR, the oncologist is able to transmit summary recommendations to their profiles based on this information. The oncologist finishes his day by submitting a treatment

plan to the inpatient system via the EHR. At one point, he accidentally orders chemotherapy mixed in saline when it should be mixed in dextrose solution. The EHR quickly fires a pop-up window pointing out the error and then goes on to assist him in calculating the best doses of chemotherapy to treat DS' cancer given her genetic risk profile, weight and kidney function.

DS is admitted to the hospital exactly five weeks from the moment that she first clicked on the link describing the need to get a mammogram. She is greeted first by a young resident physician who asks her some questions and reviews her responses to previous questions that DS has given. DS asks this young doctor for a sleeping pill because she has been nervous about getting admitted to the hospital for the first time. The resident agrees and uses a computer at DS bedside to order the most common drug for sleep. The computer quickly reacts to this order and informs the resident that this drug will have a very serious reaction if given at the same time as DS' chemotherapy. The computer recommends an alternative drug which will have no interaction at all. The resident, quickly informs DS of the change in plans for her sleep pill, orders the drug, and confirms the doses of her chemotherapy and other drugs which have already been ordered by her oncologist.

That evening DS has a conversation with her primary nurse about some annoying symptoms she is experiencing. After using structured forms to record the pertinent data, the nurse confirms her suspicions about the cause and treatment of these symptoms using knowledge resources linked to the record, and gives a medication from the 'as needed' orders which quickly resolves the symptoms. DS takes her sleeping pill that evening and has a good night of sleep despite chemotherapy running into a catheter in her arm.

Each day during her hospital stay, DS sees the physicians and nurses using information technology to clarify and optimize her treatment. On rounds in the morning, resident physicians turn a computer screen toward DS and show her positive trends in her vital signs and urine output. When her temperature goes up slightly, the resident physicians are able to show DS how this was an expected reaction to the timing of one of her chemotherapy drugs.

On the day she is to leave, one final crisis is averted when the computer systems identifies a subtle but alarming trend in her kidney function when compared with the blood level of her chemotherapy drugs. The physicians review this finding on the electronic record and prescribe a lower dose of the pill form of this drug to be taken after discharge. They also send an alert to the outpatient EHR that will be converted into a recommended order to check DS' kidney function during her next visit.

Throughout the rest of DS' journey through treatment for breast cancer, she returns time and again to her PHR for educational advice and communication with her doctors. For a while she participated in a confidential chat room for women in

her stage of treatment. The information and support she received there allayed many of her concerns and provided practical tips for dealing with every day problems associated with her diagnosis and treatment. As a result of this experience, DS regularly uses her PHR to track health maintenance issues and access CDS tools to support decision making about her personal and family's health.

Behind the Scenes

All the health-related knowledge that is brought to bear throughout DS' experience with breast cancer is delivered in a manner designed to optimize its value and appropriate application. Whenever CDS is presented, it is seamlessly linked to the related body of educational information so that recipients can appropriately interpret and respond to the knowledge.

Knowledge flows behind the scenes as smoothly as it does for DS and her care team. For example, widely used standards for encoding knowledge in human- and machine-readable formats help ensure that that this information can readily be incorporated into the information systems that underpin workflow – particularly, DS' PHR and the clinical information systems in her doctors' offices and the hospital.

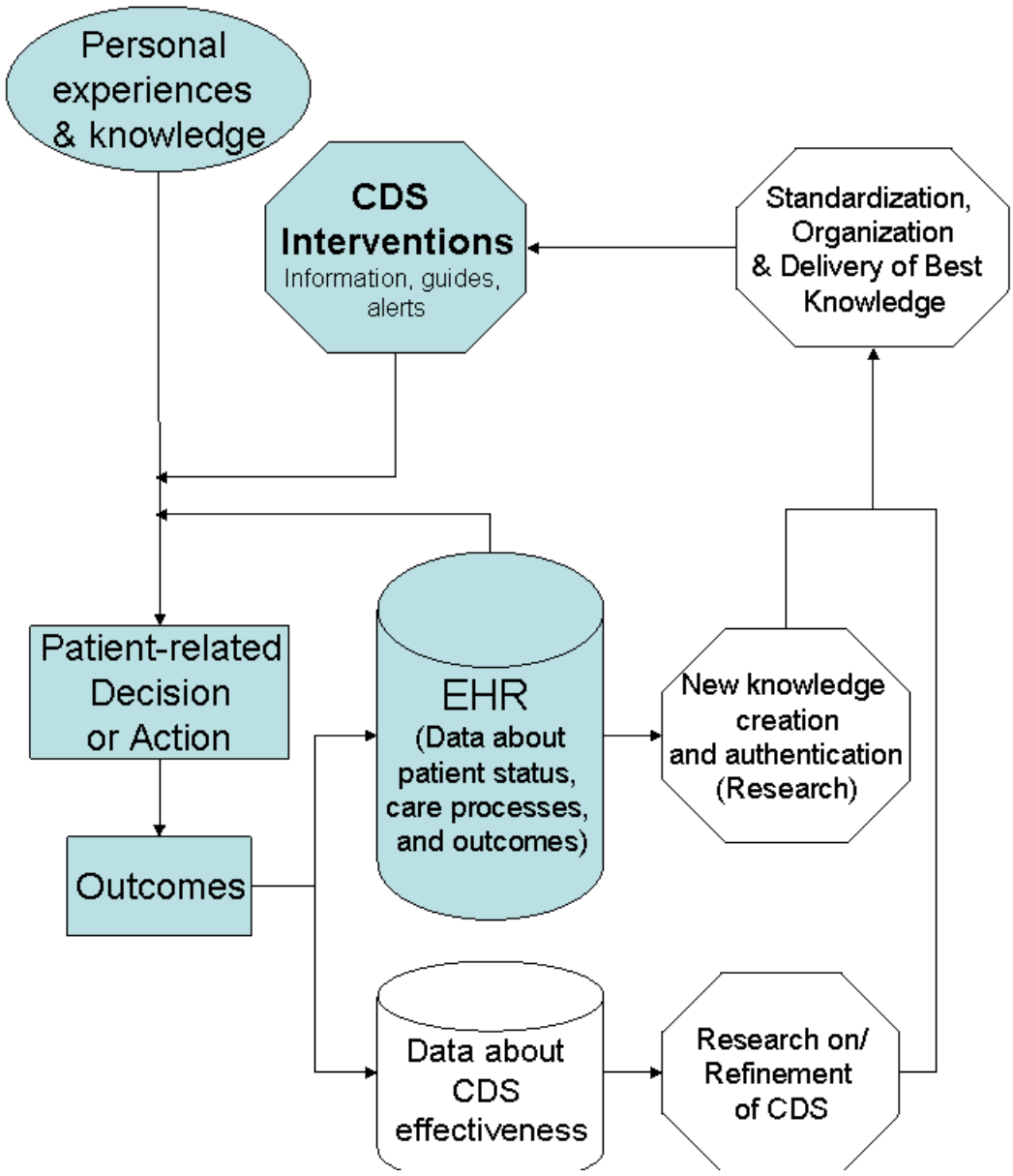
Knowledge dissemination services make it easy for information system vendors and the care delivery organizations to identify, evaluate, and deploy pertinent knowledge in CDS interventions within the information systems. Legal, regulatory, and financial enablers all support CDS implementation, making it easier and more cost-effective for knowledge providers and users to develop and implement CDS aggressively to provide maximum clinical value.

Because delivering pertinent knowledge is necessary but not sufficient for enhancing decisions, guidance and tools to facilitate clinical learning and best CDS implementation practices are readily available and widely used. For example, knowledge services include educational resources on the clinical subject matter of the intervention, as well as implementation guidance about the CDS deployment aspects of intervention. This helps ensure that the CDS interventions effectively drive behavior change in targeted individuals and desired outcome improvements.

The details of DS' care processes and outcomes feed back into the national knowledge base on breast cancer diagnosis and therapy to facilitate the refinement of this care-guiding information. Similarly, information about the processes and outcomes of the clinical knowledge delivery (i.e., which CDS interventions were useful and which could be improved) is added to the national knowledge base on CDS implementation. This implementation knowledge is used nationally to ensure widespread use of the most efficient and effective CDS implementation practices and ongoing refinement of these best practices.

Figure 1: Overview of Processes for next-generation CDS.

This Roadmap outlines how addressing the un-shaded components of this diagram in a more systematic and standardized way can help optimize clinical decision making and the resulting outcomes.



A Model for Next Generation CDS

The above scenario presents a series of activities that relate directly to the patient and clinicians (i.e., the shaded elements in Figure 1). It also describes a set of activities that may not be evident

to the individuals who are informed by CDS interventions (i.e., the unshaded elements in Figure 1). Optimizing the quality, wide availability, and successful use of clinical knowledge and CDS interventions depends on these supporting activities being performed in a more systematic and standardized way.

Thus, the challenge facing the United States is to create a health care environment in which:

- the best available clinical knowledge is well organized, accessible to all, and written, stored and transmitted in a format that makes it easy to build and deploy CDS interventions that deliver the knowledge into the decision making process
- those tools are widely implemented, extensively used, and produce significant clinical value while making financial and operational sense to their end-users and purchasers
- both CDS interventions and clinical knowledge undergo continuous improvement based on feedback, experience, and data that is easy to aggregate, assess and apply.

As illustrated in Figure 2, these three elements or pillars of a robust CDS environment provide the framework for structuring efforts to increase effective use of currently available CDS interventions and building next generation CDS. To establish a robust systematic approach to CDS for the entire health sector, both public and private organizations must collaborate on reaching six strategic objectives that align with the three pillars. These objectives and a description of the corresponding envisioned future that will result from achieving each objective appear in Table 1. The critical path activities, including deliverables in the straw man proposal for demonstration of scalable, outcome-enhancing CDS, are intended to create near-term progress toward fully achieving the six strategic objectives (See Section VI).

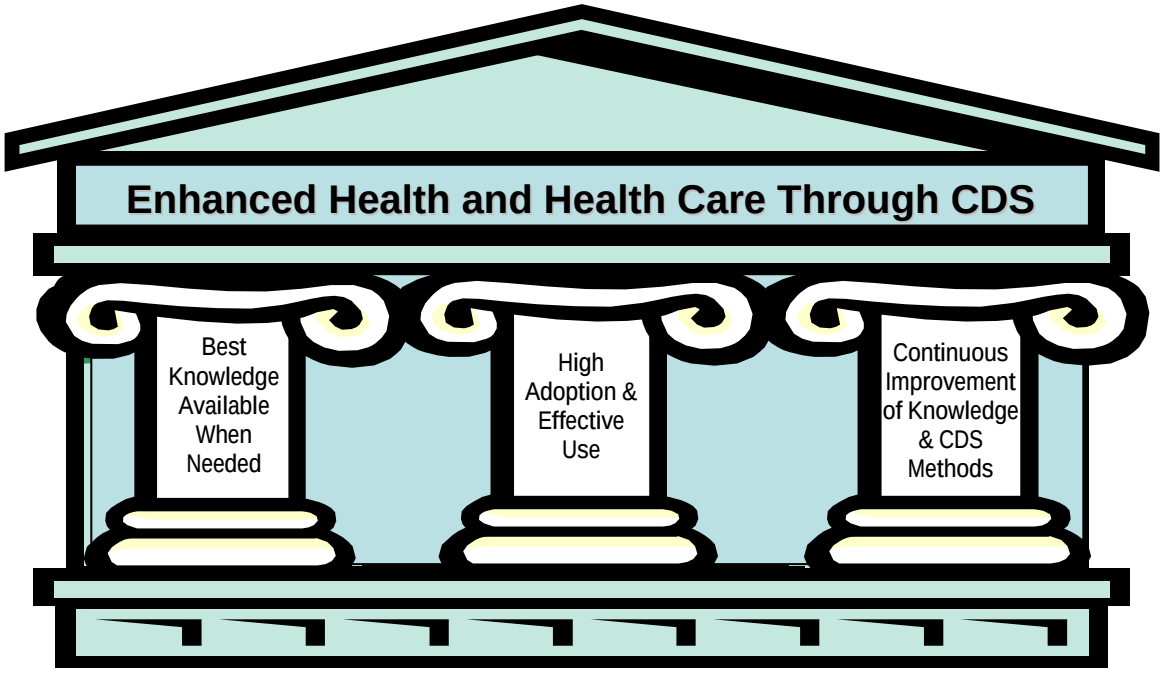


Figure 2: The Three Pillars for Realizing the Promise of CDS

Table 1: Strategic Objectives and Envisioned Future for Next Generation CDS

PILLAR 1: BEST KNOWLEDGE AVAILABLE WHEN NEEDED

***Strategic Objective A*: Represent clinical knowledge and CDS interventions in standardized formats (both human and machine-interpretable), so that a variety of knowledge developers can produce this information in a way that knowledge users can readily understand, assess, and apply it.**

Envisioned Future

- Common and practical formats for expressing specific health-related knowledge, and the CDS interventions used to deliver it, in both human-readable and machine-readable form, that enables the knowledge and interventions to become 'plug and play' is available and widely adopted. The formats include elements that facilitate localization and customization of the knowledge as appropriate for specific implementations.
- Producers of information that will be used to drive CDS interventions provide the information in these standard formats in order to minimize the costly and time-consuming need to translate from published form to executable/shareable knowledge.
- A health information system vendor/developer can access the essential elements of a CDS intervention (e.g., basic type of intervention, key parameters, best workflow step in which to apply it) with its associated clinical knowledge, and incorporate the CDS intervention (e.g., order set, clinical reminder or rule) directly into its systems, because those systems can readily accept this format without requiring significant software modification for each new intervention.
- Processes used to synthesize evidence and other types of information into recommendations and other knowledge and interventions are described in a standard way to help knowledge users assess information quality (e.g., currency, evidence-base, review/validation) and applicability.
- Knowledge users can readily see the key parameters of an intervention and can modify them for their unique circumstances if needed.

***Strategic Objective B:* Collect, organize, and distribute clinical knowledge and CDS interventions in one or more services from which users can readily find the specific material they need and incorporate it into their own information systems and processes.**

Envisioned Future

- When an entity wants to achieve a particular health or care delivery goal by deploying a CDS intervention, it can go to a trusted place or service, (herein referred to as a 'knowledge service'), easily identify one or more interventions and other materials that serve this goal, assess the material's quality and applicability, and integrate it into the knowledge delivery infrastructure in its environment (e.g., health information systems).
- The interventions and other CDS information are represented in the form described in Objective A, and are stored/served/distributed from the mechanism that is defined here in Objective B. CDS implementers can trust that any knowledge service developed according to these representation and delivery standards will be compatible with their own clinical information systems in which these CDS interventions will be deployed.

- Information and tools to support successful intervention deployment is also available from the knowledge service(s) and other sources (see Objective D). To help ensure that the interventions they provide effectively drive improvement, knowledge services can include education and implementation guidance about the clinical subject matter of the intervention for use by both CDS implementers and end-users. They can also include education and guidance about the CDS deployment aspects of intervention, including feedback from other implementers.

PILLAR 2: HIGH ADOPTION AND EFFECTIVE USE

Strategic Objective C: **Address policy/legal/financial barriers and create additional support and enablers for widespread CDS adoption and deployment**.

Envisioned Future

- It makes good business sense for health care organizations, payers and others to fully utilize CDS as a tool for driving better health and patient care outcomes.

Strategic Objective D: **Improve clinical adoption and usage of CDS interventions by helping clinical knowledge and information system producers and implementers design CDS systems that are easy to deploy and use and by identifying and disseminating best practices for CDS deployment.**

Envisioned Future

- Everyone who wishes to implement CDS to improve outcomes understands the best ways to achieve a successful deployment, and can use these approaches to efficiently achieve their goals.
- This information is available in a variety of practical, useful formats (e.g., guidebooks, courses/presentations, case studies, implementation tool libraries, peer-support).
- Best CDS practices are provided for the full spectrum of settings (e.g., information system-rich and lean environments), environments (self-care vs. health system), users, practice types, etc.

PILLAR 3: CONTINUOUS IMPROVEMENT OF KNOWLEDGE AND CDS METHODS

Strategic Objective E: **Assess and refine the national experience with CDS by systematically capturing, organizing, and examining existing deployments. Share lessons learned and use them to continually enhance implementation best practices.**

Envisioned Future

- All experiences resulting from applying CDS to health and health care in this country are captured and incorporated into a knowledge base on CDS deployment and effectiveness. For example, knowledge users can assess the actual results other organizations have achieved as a result of implementing specific CDS interventions.
- This CDS intervention experience reporting is used to provide feedback on interventions and existing processes, and leads to further refinement of and value from CDS implementations.

For example, health care organizations can access cumulative information about the use of a particular intervention as measured by the number of times it was accessed per clinician or "eligible patient"; acceptance of the suggestion as measured by the percent of time that the clinical action suggested by the intervention was taken by the clinician; effect of the intervention as measured by the organizations performance on the underlying safety, quality or financial measure the intervention was designed to improve.

- Research specifically targeted to studying the impact of and implementations strategies for CDS has a steady funding source.
- This knowledge is used to drive continuous improvements in the application of CDS to health improvement by CDS implementers and end-users, clinical information system and clinical knowledge producers, payers, policymakers and others.

Strategic Objective F: **Advance care-guiding knowledge by fully leveraging the data available in interoperable EHRs to enhance clinical knowledge and improve health management.**

Envisioned Future

- The detailed data that interoperable EHRs will contain about individual health practices and interventions, and the outcomes generated as a result, is a wellspring for new and refined knowledge about how to optimize health.
- Appropriate recipients or agencies can receive anonymous reports of medical errors and near-misses, both consumer and provider generated, to help identify where CDS should be applied (along the lines of similar processes in aviation and other industries).
- Robust processes and tools will facilitate translation of this knowledge into new best clinical practice information that will be used (via CDS and related approaches) to drive further improvements in health.

III. The Case for CDS

Despite the many advances achieved in health care during the last 50 years, the United States health system began the 21st century with a frank assessment of its deficiencies in patient safety and quality of health care services. The highly publicized 2000 Institute of Medicine report, *To Err Is Human: Building a Safer Health System*, outlined the pervasiveness of medical errors in routine health care and the potential danger those errors pose for patients on a daily basis (IOM, 2000). In 2001, the IOM catalogued studies of underuse, overuse, and misuse of care and concluded the performance of the U.S. health system "has floundered in its ability to provide consistently high quality care to all Americans" and noted that the system "frequently falls short in its ability to translate knowledge into practice." Thus, the IOM described the U.S. health system as facing "a large chasm between today's system and the possibilities of tomorrow" (IOM, 2001). Subsequent work has reinforced these findings. In 2003, the RAND Corporation found that on average patients receive recommended care only 54.9 percent of the time (McGlynn et al., 2003).

One of the causes of this chasm is the gap between the most current and evidence-based clinical and health knowledge, and the information that is typically applied in making health and care decisions. In an analysis of how long it takes to translate new findings from basic and applied research into usual and customary health care practices, Balas and his colleagues found that it may take as long as 17 years to apply 14 percent of research knowledge to patient care (Balas et al., 1998). And as the knowledge base grows, the gap widens. It is estimated that the medical literature is doubling every 19 years, and in some fast-moving subspecialties, such as AIDS-related health care, it may be doubling every 22 months.

Thus, making scientific evidence and clinical best practices more useful and accessible to clinicians and patients is one of the key strategies for crossing the quality chasm and transforming the health system (IOM, 2001; IOM, 2004; DHHS, 2004). CDS provides the mechanism by which this can be accomplished and in so doing adds substantially to the value of health information technology such as EHRs and CPOE that is widely promoted as key to addressing health care ills. Interoperable EHRs can enhance patient care through more accessible, accurate, complete data about patients. Computerized provider order entry (CPOE) can facilitate workflow and minimize transcription errors. The storage, connectivity, and automation functions of EHRs and CPOE are necessary, but not sufficient to reach the desired gains in health care quality. It is only through CDS that EHRs and CPOE can achieve their full potential for improving the safety, quality and cost-effectiveness of care. As outlined in the scenario in section II, the guides, prompts, alerts, education, data management tools and other support provided by CDS enables fully informed decision making to become a part of the normal routines.

For example, CPOE can assist physicians writing orders by streamlining and structuring the order entry process (Teich et. al., 1995; Kaushal, Shojania, and Bates, 2003).With CDS capabilities, such systems may also insure completeness and correctness of medication and other therapeutic orders, as well as diagnostic and procedural orders (Bates, Kuperman, and Teich,

1994; Bates, 2005; Teich et. al., 2000). This includes insuring the orders are executed with appropriate timing, associated orders and interventions, and follow-up studies as necessary. In addition, automated checking within order entry systems for medications can prevent untoward drug interactions (Kuperman et. al., 1994; Bates and Yu, 2003; Gurwitz et al., 2005; Morimoto et al., 2004; Yu, 2005) and allergic reactions (Bates et. al., 1998; Abookire et. al., 2000; Kuperman, Gandhi and Bates, 2003; Kuperman et al., 2003). Also, electronic records systems linked to order entry systems with CDS can supply patient data needed to perform drug dosing adjustment calculations based upon patient weight, age, renal function, or other physiologic parameters (Chertow et. al., 2001; Bates and Gawande, 2003) to prevent dangerous or ineffective drug dosing.

Evidence to Date

A systematic review of literature on the effect of health information technology on quality, efficiency, and costs of care found that three major benefits on quality were demonstrated – increased adherence to guideline-based care, enhanced surveillance and monitoring, and decreased medication errors (Chaudhry et al., 2006).

CDS has been shown to have an impact on utilization of expensive medications, and radiologic tests and procedures. CDS, at the time of order entry in a computerized provider order entry system can help eliminate overuse, underuse, and misuse (Teich et. al., 2000; Bates et al., 2003; Austin et al., 1994; Linder, Bates and Lee, 2005; Tierney et al., 2003). For medications, this effect on use might include suggesting brand to generic substitutions for medications; alternative, more cost-effective therapies, or more formulary compliant drug options (Teich et. al., 1999; Fischer et. al., 2003; Wang et al., 2003). For expensive radiologic tests and procedures this support at the point of ordering can guide physicians toward the most appropriate and cost effective, radiologic tests (Harpole et. al., 1997; Bates et al., 2003; Khorasani et al., 2003). Other maneuvers during order entry, such as showing the cumulative charge display for all tests ordered, reminding about redundant tests ordered, providing counter-detailing during order entry, and reminding about consequent or corollary orders may also impact resource utilization (Overhage et. al., 1997; Bates et. al., 1999; Bates and Gawande, 2003; Bates, 2004; McDonald et al., 2004).

An emerging set of evidence suggests that the economic value of CDS is considerable. A CITL (Center for Information Technology Leadership) analysis of the value of CPOE in ambulatory settings found that the most profound impact arises with sophisticated clinical decision support (Johnston et al., 2003). Advanced CPOE systems were estimated to cost nearly five times as much as basic CPOE, but were projected to generate over 12 times greater financial return. The CITL model projected annual savings of approximately $44 billion from reduced medication, radiology, laboratory, and ADE-related expenses and a reduction of more than 2 million adverse drug events (ADEs) annually with nationwide implementation of ambulatory CPOE. Savings of almost this magnitude may arise when computerized provider order entry technologies are adopted across every hospital (Birkmeyer et al., 2002).

Looking Ahead: CDS in Personalized Medicine

CDS may have a critical application in helping providers in the near future sort through myriad genetic tests for their patients, or correlate highly customized or personalized therapeutic regimens to a patient's genetic profile. Some experts estimate that in just a few years primary care physicians will have to know how to employ as many as 100,000 new genetic screening tests (Kucherlapati, 2006). CDS in the era of personalized medicine will also help notify clinicians when one of their patients might be eligible for a pertinent clinical trial based on either their genotypic or phenotypic patient characteristics. The vision for personalized medicine will not, however, be fully realized without rich utilization of workflow-integrated, genomics-related clinical decision support for clinicians and patients.

IV. Current Status of CDS

CDS has been deployed effectively in a few settings, but its full potential for optimizing health in the US is far from realized (Chaudhry, et al., 2006). In the current health care environment, only a small percentage of caregivers use clinical information systems that provide more than very limited CDS capabilities. Even where CDS is deployed, the implementations often do not effectively use and present the best available clinical knowledge, thereby limiting impact and the degree of clinical improvement. More specifically, in 2006, drug-drug interaction checking modules and drug-allergy checking modules are the primary CDS interventions that are routinely being purchased and implemented. Most organizations that use CDS do not have dose checking capabilities. Some current CDS systems generate too many "false positive" alerts, or interrupt clinical workflows in a manner that can disrupt efficient care delivery (Koppel et. al., 2005; van der Sijs et al., 2006). As a result, some clinicians and institutions sometimes "turn off" the CDS capabilities within the commercial systems that they purchase. Alternatively, clinician-users may "tune out" all decision support messages because the majority of them have little clinical significance (Murray et. al., 2004; van der Sijs et al., 2006). The nascent state of CDS is due in part to the complexity that arises from the nature of decision making, the intellectual challenge of creating knowledge, technical dimensions of delivering CDS, and social aspects of incorporating changes into clinical care.

Challenges for Information System and Knowledge Developers

One of the major factors limiting the full adoption and impact of CDS is a lack of a common and transportable base of clinical knowledge and CDS interventions that can be easily and widely used in electronic health records (EHRs) and other clinical information systems. Largely non-standardized and independent approaches to creating and presenting clinical knowledge and CDS interventions severely limit incorporation, re-usability, and interoperability in clinical information systems. There is not yet an explicit overarching vision for a suite of CDS-related standards that will lead to widespread, effective use of CDS interventions. Individual CDS standards that are available (e.g., Arden Syntax (Pryor and Hripcsak, 1993)) are generally not widely deployed, and may not optimally address pertinent implementation challenges.

Data that drive patient-specific CDS interventions also need to be accessible in a standardized format. For example, if an alert is to fire when patients on a particular medication have a certain laboratory abnormality that could present a substantial danger, ideally the logic that checks for the co-occurrence of the medication and abnormality should use standard terms to detect these items. Without widespread use of such standardized vocabularies to trigger CDS interventions, CDS implementers often have to hand craft such triggers into each implementation. Although there are solid and emerging standards for many of these triggers (such as LOINC (Forrey et. al., 1996), ICD-9, RxNORM, CPT, and SNOMED-CT), and some coordination efforts beginning (e.g., the Healthcare Information Technology Standards Panel; HITSP, 2006), completion and widespread deployment of patient data standards are needed to fully support patient-specific CDS.

The inability to implement CDS features that work well in one clinical information system in a different system leads to significant waste. At a minimum, existing knowledge often must be re-encoded and adapted to be used across vendor systems or even across different applications within the same vendor system. Unnecessary redundancy and rework, and significant potential for errors and sub-optimal CDS deployment, occur as each organization tries to develop its own interventions, or fit knowledge that is not plug-and-play into their systems. Such multiple "reinventing-the-wheel" processes limit the availability of good CDS tools, as each manufacturer and implementer of such systems struggles to develop the same interventions, or, for lack of time and ability to do so, simply leaves out CDS interventions that could deliver important benefits.

Further, current methodologies and mechanisms for developing and disseminating medical knowledge systematically are inadequate. Today approaches such as data mining, government efforts such FDA's Medwatch, and health services and outcomes research are generating some new clinical knowledge. However, using large databases of patient information that might be helpful for data mining and analysis is often difficult because these databases may be structured in non-standard-ways, and may contain data that is problematic to compare due to nonstandard or uncontrolled representation. In addition, access to the data may be limited due to HIPAA restrictions (real or imagined). We are at the very earliest stages of envisioning how to capitalize on the full potential of ready access to rich health data about the entire population from interoperable EHRs, but intensive efforts to disseminate these systems presents an important opportunity to begin exploring how to do this better.

Clinical knowledge and CDS interventions for use in clinical information systems currently can be obtained from a variety of sources whose formats are non-standard and accessibility is variable (e.g., HIS vendor's shared libraries, commercial CDS content publishers, the Internet). Thus, finding the most useful clinical knowledge and CDS interventions to meet a specific need from the universe of potential sources is often difficult. Lack of inter-operability between different content sources and information systems can limit options. Further, inconsistent approaches to documenting the quality of CDS content make it difficult for knowledge consumers to assess quality and applicability. Mechanisms for incorporating the knowledge into clinical information systems are highly non-standard, and generally manual and inefficient. Although ongoing review and maintenance of CDS is essential as clinical knowledge changes, there is no recognized process for determining when there is enough evidence to warrant change in the knowledge content or triggers of CDS interventions.

Challenges for Users

A relatively small proportion of end-user and organizational experience with CDS is made available so that others can benefit from this experience. When there is reporting, because CDS interventions are implemented and described in non-standard way, it is difficult to draw lessons that can be applied in other settings. The extent to which various CDS interventions are being used is relatively limited, not well known, and not tracked. A small but growing body of research has examined the process and results from CDS implementation. The studies that are currently available generally do not follow standardized approaches for evaluating the systems, so comparing and synthesizing results across studies can be problematic. The feedback loop to

Clinical information system (CIS) and CDS/knowledge producers from research and experience about principles for effective CDS deployment could be strengthened considerably.

There has been some progress in synthesizing best practices and providing 'how-to' information for developing and implementing CDS interventions (Kawamoto et al., 2005; Osheroff et al., 2005). There is, however, still a lot of re-inventing the wheel, and many implementations fall short, or fail altogether, because key principles and tactics learned by others are not widely known and applied. This applies to the adoption of CDS itself and also to the adoption of the tools and applications (such as clinical information systems) that deliver it. It is still a common belief and experience that CDS is difficult to implement efficiently and anticipated benefits are elusive. The art and science of when and how in workflow to provide CDS to optimize the efficiency and value of information delivery is young, and there is much more to learn.

Additionally, clinical experience with CDS is not easily shared among different venues of care and is only slowly fed back to information systems producers. For example, delivering proactive clinical decision support such as unsolicited alerts to clinicians in a manner that improves outcomes without adversely impeding workflow is a major challenge that health care organizations struggle with virtually in isolation. Many current sites desiring deeper and more user-accepted CDS are frustrated by a range of problems with available toolsets in the commercial systems they have purchased. Many vendor solutions offer a limited, unwieldy CDS toolset that does not address many well documented gaps in medication safety and quality. Because these tools vary from vendor to vendor, deploying organizations generally can not follow standardized and optimized approaches to tuning these interventions to optimally fit their organization's needs (Koppel et. al., 2005; Sittig et. al., 2006)

In addition, institutions may need to customize the knowledge base underlying their CDS system, yet the tools for doing this are inadequate. Currently, customization requires a careful interplay among the application vendor, the knowledge base vendor, and the user organization. Few organizations have demonstrated the ability to manage this level of collaboration and complexity, and even successful approaches are not scalable industry-wide. Some implementations have solved key deployment challenges, but there are very limited channels for passing the secrets of that success on to others. Thus, lessons learned in clinical use, which could be used to greatly improve the efficiency, acceptability, and value of CDS tools, are translated into improved products and implementation strategies very slowly, if at all.

Many of the most robust opportunities to deliver CDS into workflow leverage sophisticated clinical information systems that increasingly underpin clinical workflow (e.g., EHR, CPOE, and PHRs.) However, these systems can be complex and costly to implement themselves, even without added CDS capabilities. Because at this point the diffusion of these systems in the U.S. is relatively limited, and in some cases problematic, the opportunities for layering on CDS functionality is correspondingly limited. Heightened national attention to more widespread adoption of HIT provides an ideal window now for ensuring that CDS capabilities track closely with this accelerated system diffusion so that these systems ultimately deliver their intended benefits.

Organizational issues also influence the success of CDS adoption. Fragmented information systems, fragmented departments within health care organizations, and fragmented care between specialists make it difficult for CDS applications to have access to the full set of patient data and thus impede effective CDS use. Many health care organizations do not coordinate CDS activities. Instead, they are often scattered over different departments and decisions are made in one area that affect another area without careful consideration of this interplay. As emphasized in CDS implementation guides, larger organizations and delivery systems will likely benefit from better coordination of CDS activities (Osheroff et al., 2005).

Lack of follow through on implementation and training is another potential pitfall for organizations in deriving optimal benefit from CDS. For example, in some cases installing an EHR system and addressing the concomitant workflow and other organizational changes is such a major undertaking in itself, that implementing CDS functionality available in the system, or providing adequate training on this functionality, becomes a secondary concern.

The full benefit of CDS is also limited by critical barriers to adoption faced by health care providers and health systems. Currently, the health care information marketplace is stymied by misaligned financial incentives, low capital availability, and inadequate maturity and uptake of relevant health care information technology standards. Clinicians sometimes resist the use of CDS systems for fear that they will reduce autonomy or increase liability. Other providers want to have the improved safety and quality that CDS brings, but cannot financially justify the purchase of such tools because the reimbursement structure offers no benefit for acquiring or using them (the way that it does, for example, for the use of a new diagnostic procedure). Many organizations do not recognize a clear business case for financial and organizational investments in developing and executing a plan to optimize application of CDS. As in the case for other health care information technologies, the costs associated with CDS implementation is typically borne primarily by health care organizations while many of the benefits accrue to patients, payers, and society as a whole in terms of improved health care. Supportive policies and new financial incentives would help to redress these deficiencies and facilitate adoption of CDS tools more quickly and broadly.

Challenges for Evaluation of CDS

Significant challenges accompany any CDS evaluation. Experimental design is complicated by the different software systems, users and environments where CDS is deployed. System developers often evaluate their own systems, and their conclusions may not be viewed as independent or be applicable to disparate settings. Researchers attribute difficulty in accessing patient data to aggregate for analysis to HIPAA regulations. There is currently no mechanism for post-marketing surveillance of CDS or infrastructure for continual improvement of CDS interventions (Miller and Gardner, 1997a; Miller and Gardner, 1997b). As a starting point, CDS systems need to be designed to provide data on how many times CDS interventions are presented and/or accessed, and what impact this has on decisions made (e.g., rates of alert firing and acceptance or rejection of the recommendations). Organizations implementing CDS also need access to this type of information to understand the effectiveness of these tools and fine-tune their use

V. Comprehensive CDS Work Plan

This section identifies key questions and controversies to resolve, and recommends short-term, mid-term, and longer term tasks, as well as maintenance or governance structures needed to accelerate the successful realization of each of the six strategic objectives identified in Section II. Each recommended action includes identification of who should be involved in the activity, and how it might be approached.

The types of activities recommended to advance the six CDS strategic objectives include:

- Organize consensus panels and reports to address specific issues
- Design key technical and informational elements in HIT infrastructure
- Create/reconcile standards, vocabularies
- Build/enhance organizational structures and entities
- Develop/advocate for policies – legislative, regulatory
- Cultivate new and ongoing financial support where needed
- Encourage/facilitate collaboration within and among key stakeholder groups
- Educate and communicate with stakeholders
- Write white papers, research reports to convey results of activities above

These activities will involve both public and private sector participation from a wide range of stakeholders. These stakeholders include those groups that will have a role in creating an environment that supports and promotes CDS, the content for CDS systems, the delivery mechanisms for CDS, and the actual use of CDS. These groups include, but are not limited to:

- **public agencies** and entities such as ONC, AHIC, AHRQ, the Food and Drug Administration (FDA), National Institutes of Health (NIH) (including the National Library of Medicine (NLM), CCHIT, Centers for Disease Control (CDC), Centers for Medicare and Medicaid Services (CMS), Veterans Administration (VA), National Institute of Standards and Technology (NIST), Department of Defense (DOD), Departments of Agriculture, Commerce, Homeland Security, state departments of health, and the Institute of Medicine (IOM)
- **professional societies and academic organizations** such as AMIA, American Health Information Management Association (AHIMA), Healthcare Information and Management Society (HIMSS), Association of Medical Directors of Information Systems (AMDIS), American Telemedicine Association, Association of Laboratory Automation, Medical Library Association (MLA), Society of Medical Decision Making, American Medical Association (AMA), American Academy of Pediatrics (AAP), American Society of Health System Pharmacists (ASHP), National Community Pharmacists Association, American College of Physicians (ACP), American College of Surgeons (ACS), American Academy of Family Physicians (AAFP), American Society of health System Pharmacists (ASHP), American Nurses Association (ANA), and specialty certification boards

- **disease-focused organizations** such as American Cancer Society, American Heart Association, American Diabetes Association, and others
- **quality and safety organizations** such as National Quality Forum (NQF), Joint Commission on Accreditation of Healthcare Organizations (JCAHO), Institute for Safe Medication Practices (ISMP), Institute for Healthcare Improvement (IHI), National Committee on Quality Health Care (NCQHC), CMS-funded quality improvement organizations (QIOs), Ambulatory Quality Alliance (AQA)
- **University-based and other academic informatics groups** such as Clinical Research Forum, and philanthropic organizations such as Markle Foundation Connecting for Health, Robert Wood Johnson Foundation, California Healthcare Foundation, Milbank Fund, Commonwealth Fund, and Faster Cures
- **payer and health plan organizations** such as Business Roundtable, Leapfrog Group, America's Health Insurance Plans (AHIP), CMS, Bridges to Excellence
- **HIT and related industry** representatives and organizations, including Electronic Health Record Vendors' Association (EHRVA), clinical information systems (CIS) vendors, CDS content/knowledge providers (e.g., commercial vendors, voluntary organizations such as the Cochrane Collaboration), health care data analysis companies, clinical transformation consultancies, standards development organizations (e.g., HL7, SNOMED, LOINC, MedBiquitous and others)
- **consumer or patient representation** (e.g., AARP)
- **health law experts**
- **international organizations**, including the World Health Organization and International Society for Quality in Healthcare.

Strategic Objective A: Represent clinical knowledge and CDS interventions in standardized formats (both human and machine-interpretable), so that a variety of knowledge developers can produce this information in a way that knowledge users can readily understand, assess, and apply it.

Key Questions and Controversies

- What have been the successes and limitations of current and prior CDS-related standards efforts in achieving the vision (i.e. standards for creating and representing clinical knowledge and CDS interventions)? How do these approaches compare with the way CDS is deployed in currently-used EHRs and health information systems?
- What will it take to make a standard CDS approach implementable in such systems (focusing on ease of implementation in real-world care settings)?
- Should there be (one or more) standardized approaches for documenting and assessing the quality (e.g. evidence base, currency, validation) of CDS content?
- Who should verify the quality of CDS content?

Table A: Recommended Actions for Standardized CDS Representation

	Near-term Tasks and Deliverables	**Who/How**
A.1	Prepare reports or white papers that a. Catalogue current and prior CDS-related standards and harmonization efforts[5]. b. Identify gaps to realization of the vision for clinical knowledge and CDS interventions being represented in a standard format. c. Identify the successes and limitations of current and prior CDS-related standards efforts in achieving the vision (i.e. standards for creating and representing clinical knowledge and CDS interventions). d. Describe how these approaches compare with the way CDS is deployed in currently-used EHRs and health information systems. e. Describe what it will take to make a standard CDS approach implementable in such systems (focusing on ease of implementation in real-world care settings). f. Describe best practices for documenting and assessing the quality of CDS content.	Contracted writer(s) with oversight from CDS Roadmap Execution Steering Group[6], input from participants in prior standards efforts, review by expert panel
	Mid-term Tasks and Deliverables	**Who/How**

[5] See Appendix D for preliminary compilation of clinical knowledge representation formalisms, and pointers to ONC and federal HIT activities where standards harmonization initiatives are outlined.
[6] See Section VI of this report where the recommendation to establish the Roadmap Execution Steering Group is presented.

A.2	Prepare a consensus statement on whether there should be (one or more) standardized approaches for documenting and assessing the quality (e.g. evidence base, currency, validation) of CDS content.	Various stakeholders (e.g., evidence-based medicine (EBM) experts, AHRQ, specialty societies, CDS content providers).
A.3	Develop standards for practical representations of clinical knowledge and data (e.g. problem lists, orderable medications) as well as the CDS interventions that deliver them. • Include elements to assist knowledge users in assessing clinical knowledge quality and applicability and localizing it as appropriate. • Include an enforcement policy and strategies to support adoption of these representations (e.g. standardized order sets) by clinical knowledge producers and clinical information system vendors. • Ensure that the representations support both machine-readable and human-readable uses of the knowledge.	Coordinated by federal agency (e.g., AHRQ, NLM, ONC) or vendor/customer collaborative. Multiple stakeholders and sources of input: knowledge users, CIS and CDS producers (to define requirements and action plan); pertinent standards organizations, and HITSP; EBM experts, AHRQ, specialty societies.
A.4	Identify funding needs and sources to promote coordination of standards for clinical knowledge and CDS interventions.	CDS Roadmap Execution Steering Group in consultation with appropriate public agencies and private organizations.
	Longer-term Tasks and Deliverables	**Who/How**
A.5 A.6	Develop a prototype for education content on standardized format of clinical knowledge and CDS interventions that could be adapted for various audiences (e.g., health professional students, health professionals, researchers, CDS system developers). Develop a marketing and communication plan for promoting adoption of standardized formats for clinical knowledge and CDS interventions with particular attention to reaching publishers, SDOs, coordinating bodies, and CDS end users.	Working group of appropriate stakeholders, convened with input from CDS Roadmap Execution Steering Group.
A.7 A.8	Develop strategy (e.g., language for legislation, sponsorship) for obtaining federal appropriations to support standards for clinical knowledge and CDS interventions. Identify or establish an overarching entity responsible for developing/harmonizing CDS-related standards.	CDS Roadmap Execution Steering Group in consultation with appropriate agencies.

Strategic Objective B*:* Collect, organize, and distribute clinical knowledge and CDS interventions in one or more services, from which users can readily find the specific material they need and incorporate it into their own information systems and processes.

Key Questions and Controversies

- What lessons and tactics useful for CDS knowledge and intervention dissemination can be gleaned from similar initiatives in other areas?
- Should there be one or several CDS knowledge services? Can it/they aspire to being global? Should they be run only as a public service, or can private entities also sponsor such services?
- What technical models and infrastructure for content uploading/downloading/management are needed (including standardization and computability features)?
- What business models are needed? How would it be authorized and governed? How would its contents be validated? What entities are entitled to certify or approve a knowledge service?
- What safeguards are necessary to protect intellectual property while still facilitating sharing of knowledge? How does it relate to current medical publications and knowledge distribution services?
- What would the format be for knowledge and interventions in such a knowledge service? What elements should it contain? What functionality is necessary for easy and useful addition, editing, and access?
- How will services be updated and version control managed?

Table B: Recommended Actions for Organization and Distribution of CDS

	Near-term Tasks and Deliverables	**Who/How**
B.1	Prepare reports or white papers that a. Assess and critically review current and prior efforts (both successful and unsuccessful) to manage and disseminate clinical knowledge and CDS interventions (e.g., National Guideline Clearinghouse, GEM, DailyMed, PRODIGY, Guideline International, IMKI, SAGE, commercial knowledge services). b. Outline features and pros/cons of knowledge management and distribution efforts, with implications for next steps toward achieving the vision above. c. Describe cross-industry comparisons for effective decision support practices, compare and contrast with health care practices, and make recommendation for functional and technical model for health care. d. Offer market analysis of alternative business models for knowledge management and dissemination. e. Describe best practices for knowledge services.	Contracted writers with guidance from CDS Roadmap Execution Steering Group.

	Mid-term Tasks and Deliverables	Who/How
B.2	Prepare a consensus statement on the public sector role in strengthening knowledge management and dissemination in the health industry as a strategy for advancing effectiveness of health care delivery in the U.S.(including creating incentives for or removing barriers to private sector action in this domain).	Consensus development conference. Pertinent stakeholders (e.g., knowledge users, knowledge producers, clinical information system (CIS) developers, standards development organizations (SDOs), AHRQ National Resource Center (NRC), CMS, other public/private payers, professional societies), Business stakeholders, knowledge vendors, other content producers, intellectual property (IP) legal counsel; Payers, employers, Leapfrog, Bridges to Excellence, NQF/AQA/National Committee for Quality Health Care other quality measure promulgators, etc.
B.3	Develop the standard organizing, clustering, searching constructs for a knowledge management service.	Working group of pertinent stakeholders, convened and run with input from CDS Roadmap Execution Steering Group.
B.4	Develop a tactical plan to optimize the use of currently available knowledge service precursors (e.g., guidelines.gov, Cochrane Library, CDS knowledge provider content repositories, CIS vendor shared content libraries) as transitional approaches toward the full knowledge service vision outlined above.	Working group of pertinent stakeholders, convened and run with input from CDS Roadmap Execution Steering Group.

B.5	Develop a pilot project to test next generation knowledge services a. Develop a proof-of-concept CDS knowledge service to illustrate the promise and challenges associated with such tools. b. Identify a starter set of interoperable CDS interventions to be used in this demonstration, focusing on CDS interventions for a high-priority topic – see Component D	Start with a public agency (e.g., NLM, AHRQ NRC), academic or public/private project group; involve pertinent stakeholders
	Longer-term Tasks and Deliverables	
B.6	Identify or establish a coordinating/facilitating entity with an open/voluntary structure to foster advances in accessibility of CDS content/interventions	Pertinent stakeholders as outlined above.

Strategic Objective C: Remove policy/legal/financial barriers and create additional support and enablers for widespread CDS adoption and deployment.

Key Questions and Controversies

- What are the most effective CDS driver mechanisms – pay for performance, legislation/regulation, differential reimbursement, payer-supported programs, liability relief, etc?
- How can payers be more effectively engaged creating appropriate drivers for outcome-improving CDS use? How can payers know that organizations are using CDS effectively?
- How can the environment faced by office-based providers be modified to support changes to practice management processes necessary for optimal CDS adoption?
- What overall public and/or private entities and constructs are needed to monitor and influence the various financial, regulatory/policy, legal and other key determinants of the CDS environment to make it more conducive to widespread adoption? What are appropriate roles for ONC, AHIC, professional societies, and other stakeholders?
- How can organizations recognize the development of CDS content in academic career advancement?

Table C: Recommended Actions for Removal of Policy, Legal, and Financial Barriers

	Near-term Tasks and Deliverables	**Who/How**
C.1	Review and provide input on CCHIT certification requirements to ensure that CDS features are fully and appropriately addressed in emerging CCHIT requirements. (See also C.7).	CDS Roadmap Execution Steering Group with input from key stakeholders, CCHIT
C.2	Prepare reports or white papers that: a. Enumerate specific legal, policy, regulatory, financial obstacles faced by stakeholders such as health care organizations, CIS, knowledge and CDS intervention vendors (including challenges faced by providers in rural and low resource environments) and identify solutions including recommended regulatory changes or other enabling legislative needs b. Explore alternative approaches to funding CDS implementations and ongoing enhancements in various practice settings (e.g., loan programs, liability relief) and identify ways to align sources of funding for CDS deployment with stakeholders who are most likely to benefit financially	Contracted writers with guidance from CDS Roadmap Execution Steering Group. Obtain input from ONC (especially legal/policy staff), experts on health law related to CDS, providers, risk management organizations, payers, hospitals, and practice management groups
	Mid-term Tasks and Deliverables	**Who/How**
C.3	Prepare consensus statement on role of public and private sector third party payers in supporting the costs of and creating incentives for CDS implementation.	Payers, employers, Leapfrog, Bridges to Excellence,

C.4	Develop a plan to harmonize and optimize measures and financial incentives linked to implementation of CDS (e.g., pay-for-performance programs).	NQF/AQA/National Committee for Quality Health Care other quality measure promulgators, etc. CMS, AMIA, HIMSS
	Longer-term Tasks and Deliverables	**Who/How**
C.5 C.6	Develop educational content on effective use of financial incentives to drive effective and efficient use of CDS targeted to payers Develop a marketing and communication plan for promoting use of financial incentives to encourage CDS use	Working group of pertinent stakeholders, convened with input from CDS Roadmap Execution Steering Group.
C.7	Establish ongoing mechanism to ensure that CDS is appropriately addressed in longer term CCHIT work products	CCHIT, CDS Roadmap Execution Steering Group, other stakeholders. Ongoing collaboration & consultation; carryover from CCHIT-related short-term deliverable above.
C.8	Identify appropriate public and private sector entities to monitor and influence the various financial, regulatory/policy, legal and other key determinants of the CDS environment to make it more conducive to widespread adoption	CDS Roadmap Execution Steering Group with input from other stakeholders

Strategic Objective D: Improve clinical adoption and usage of CDS interventions by helping clinical knowledge and information system producers and implementers design CDS systems that are easy to deploy and use, and by identifying and disseminating best practices for CDS deployment.

Key Questions and Controversies

- What are the top priority targets on which CDS improvement efforts should be focused in the short term (e.g., high performance on quality measures such as CMS core measures and top pay for performance measures, addressing most widespread and dangerous medication safety problems, etc.)? Who should make these decisions? What are the best CDS approaches for advancing the top targets? That is, what information, delivered in what format, to which stakeholder at what point in workflow would most effectively help achieve the specific desired objectives?
- What role can/should knowledge services (outlined above in Objective B) play in aggregating and disseminating information about best practices in CDS dissemination?
- How can the HHS demonstration projects (e.g., from AHRQ and CMS[7]) and current successful CDS programs be leveraged to gain more knowledge on how to design and implement effective and widely deployable CDS?
- What do experts in CDS view as success factors for implementing and maintaining CDS systems?
- What is the optimal approach for deploying consumer and patient-directed CDS now and going forward (e.g., leveraging PHRs)? How can patient values be incorporated into other forms of CDS? How does language, data organization and presentation, and culture impact patient/consumer CDS use and effectiveness?
- How do we reconcile differing representations and implementations of medication knowledge and decision support?
- How do we prioritize medication-related CDS?

Table D: Recommended Actions for CDS Design and Implementation

	Near-term Tasks and Deliverables	**Who/How**
D.1	Conduct discussions with specific stakeholder organizations on how CDS can advance their objectives and how they can help support CDS as a starting point for increasing attention to and leveraging resource for CDS in current initiatives a. AHIC b. CCHIT c. JCAHO d. Pay-for-performance initiatives e. IOM Roundtable on Evidence-based Medicine	AHIC and other listed organizations, CDS Roadmap Execution Steering Group
D.2	Prepare reports or white papers that a. List possible target CDS interventions and rationale with	Contracted writers with input from CDS

[7] See Appendix D for pointers to examples.

	accompanying definition of relevant standards, knowledge elements, and performance assessment methods and describe best CDS approaches for advancing selected priority targets. b. Analyze how HHS demonstration projects (e.g., from AHRQ and CMS[8]) and current successful CDS programs be leveraged to gain more knowledge on how to design and implement effective and widely deployable CDS. c. Address the range of issues associated with consumer and patient-directed CDS. d. Define what changes need to be made to drug knowledge bases, and information systems that deliver them (including real-time education systems), to optimize medication safety in the short term. e. Identify success factors for CDS implementation and maintenance activities.	Roadmap Execution Steering Group and input appropriate stakeholders.
D.3	Develop implementation guides, toolkits, and educational programs for achieving specific targets and demonstrating value with available CDS tools (e.g., the HIMSS CDS implementers' guide (Osheroff et al., 2005)). Include: a. optimal models for planning, governance, technology, implementation, and evaluation of CDS projects in provider organizations. b. approaches for minimizing alert fatigue and excessive overrides for proactive CDS interventions. c. recommendations for addressing underlying educational and cultural changes critical to CDS success. d. Link to broader educational efforts around the opportunities for improving care with CDS and strategies for implementing it successfully in a broad range of health and care-delivery settings[9]. e. guidance for CIS developers on how to incorporate CDS interventions into their systems in a manner consistent with the Roadmap principles and best practices.	Payers/health plans, health care organizations, safety/quality organizations (e.g., ISMP, NQF, AQA), Gov't agencies (CMS, AHRQ, FDA), HIMSS CDS Taskforce, others
D.4	Create 'starter sets' of major drug-drug interactions, drugs to avoid in certain circumstances, renal checking/dosing, etc. (Define relatively small, manageable sets of medications that are the best targets for such interventions because they are relatively non-controversial and have high potential for positive impact – to avoid 'alert fatigue' and provide a usable starter set). Ensure appropriate knowledge representation and exchange standards exist to support widespread adoption of this information.	Drug knowledge vendors, research pharmacists, medication safety organizations (e.g., ISMP), pertinent SDOs and CIS vendors, payor community, standards

[8] See Appendix D for pointers to examples.

[9] AHRQ has already funded related research efforts to identify best practices for CDS implementation (e.g., Steele/Denver Health grant http://www.ahrq.gov/qual/stateqprojb/stateqproj1.htm; see 290-00-00149).

		organizations. Project, possibly through AHRQ or ONC contract, to assemble stakeholders, review evidence and synthesize expert opinion, and create and disseminate the starter lists.
D.5	Establish a forum for CDS intervention recipients, implementers, CIS/CDS vendors, clinical transformation consultants, CCHIT, etc. to come together and prioritize opportunities to optimize deployment of CDS in the near and longer term. Carefully consider workflow issues, time constraints, behavior change and educational issues that affect clinician and general population use of CDS interventions, and models that minimize workflow disruption while maximizing positive benefits. Include a mechanism for bringing together into forum, and maintaining cohesiveness and productivity, of diverse stakeholders for improving CDS implementation	Stakeholders, an organizing entity (based on input from CDS Roadmap Execution Steering Group)
	Mid-term Tasks and Deliverables	**Who/How**
D.6	Prepare consensus statement on top priority targets for short-term CDS improvement efforts.	Payers/health plans, health care organizations, safety/quality organizations (ISMP, NQF, AQA, AHQA, etc.), Gov't agencies (CMS, AHRQ, FDA, etc.), others
D.7	Develop a plan for providing wider access to and use of existing CDS interventions for top priority targets.	CDS Roadmap Execution Steering Group + other interested stakeholders (e.g., ACMI/AMIA, HIMSS CDS listserve and others, NRC, Davies winners, IHI). Leverage available expert/implementer networks. Possible AHRQ grant support?
D.8	Convene standards developers and HIT knowledge vendors to	Drug knowledge and

	develop a plan for implementing needed changes in drug knowledge bases and information systems that deliver them (see D.2.d).	CIS vendors, care delivery organizations, medication safety experts (e.g., ISMP), NLM RxNorm project, quality organizations (e.g., NQF)
D.9	Establish ongoing linkages to and representation on relevant organizations in the health sector (e.g., AQA, HQA, ACQA) to incorporate CDS into their respective agenda and identify specific ways that those organizations can use CDS to support their goals.	CDS Roadmap Execution Steering Group, representatives from organizations listed. Dialogue, working group(s), possible whitepaper(s); identify convening entity that can bring together pertinent stakeholders
D.10	Identify and more fully leverage available channels for providing support to care delivery organizations for successful CDS implementation	DoQ-IT, NRC, others
	Longer-term Tasks and Deliverables	**Who/How**
D.11	Develop a marketing and communication plan that • leverages regional organizations and local champions and experts on CDS implementation • recognizes early success stories • provides standard educational materials • provides a forum for champions to exchange ideas and share lessons with new CDS participants	HIT-related societies (e.g., AMIA/HIMSS), NRC, DOQ-IT
D.12	Establish an ongoing mechanism for prioritizing national focus areas for CDS that provides opportunities for input from key stakeholders	ONC, CDS Roadmap Execution Steering Group, with stakeholders above. Consider AHIC, NQF, Others

Strategic Objective E: **Assess and refine the national experience with CDS** by systematically capturing, organizing, and examining existing deployments. Share lessons learned and use them to continually enhance implementation best practices.

Key Questions and Controversies

- What is the best way to organize and facilitate the collection, synthesis, and dissemination of evidence about CDS use practices? How can this information be best organized so that it can be practically applied to improving CDS techniques?
- How should CDS interventions be evaluated, and who should be doing the evaluations?

Table E: Recommended Actions for Assessment and Refinement of CDS

	Near-term Tasks and Deliverables	**Who/How**
E.1	Prepare reports or white papers that a. Describe how other industries and organizations (e.g., DOD, commercial air travel, energy) evaluate decision support in their fields and summarize implications for CDS b. Define a research agenda for CDS that addresses how to show value (in a variety of settings and with disparate CIS infrastructure), assess feasibility and outcomes, extrapolate lessons across settings, conduct 'post-marketing surveillance on CDS'; build conceptual models and prototypes for this analysis. c. Develop more standard approaches and metrics for describing, analyzing and reporting: CDS interventions and environments, intervention results, costs, usage, etc. as a step toward greater usefulness of CDS research. Document the extent to which CDS interventions are being used and their results, and track over time. Consider tools for aggregating and disseminating research on CDS costs and outcomes. Leverage existing published evaluation metrics and frameworks.	Contract writers and convened working groups with guidance from CDS Roadmap Execution Steering Group
	Mid-term Tasks and Deliverables	**Who/How**
E.2	Develop guidelines for reporting CDS practices and outcomes	AHRQ, NRC, DoD, VA, NIST, Others, research organizations
E.3	Work with CIS producers to link assessment more tightly and in a more standard way with CDS interventions (e.g., collecting from end-users why specific alerts are rejected). For this item and others in this table as appropriate, focus initially on the 'high priority areas' as outlined in D.6 above.	CIS vendors, CDS research experts. Working group, linkage with existing vendor organizations (EHRVA)

E.4	Develop strategy for measuring, and begin gathering data about, the use of various types of CDS in practice.	Piggyback onto other HHS initiatives (e.g., grants to measure HIT diffusion). Build on AHRQ/EPC research on CDS and the Leapfrog Group CPOE Evaluation Tool (Kilbridge, Welebob and Classen, 2001). Contract research project bibliography of research on CDS; write into pertinent HHS contracts and grants
	Longer-term Tasks and Deliverables	**Who/How**
E.5	Establish mechanisms for facilitating application of research on CDS processes, costs and outcomes to drive continuous improvement in the value of CDS implementations	CDS research experts and potential beneficiaries of that research (CDS implementers, CIS and knowledge providers)

Strategic Objective F: **Advance care-guiding knowledge** by fully leveraging the data available in interoperable EHRs to enhance clinical knowledge and improve health management.

Key Questions and Controversies

- What is an achievable and valuable shared vision for how data available within interoperable EHRs can be used to expand the health knowledge base?
- What are the key privacy issues to be considered, and how can these issues be optimally managed? Are there technological approaches for providing anonymous data that avoid privacy concerns? Should there be options for consumer participation in data aggregation initiatives for health knowledge discovery?
- How do the expanding implications of genomics knowledge and data figure in considerations for health knowledge discovery from interoperable EHRs?
- What is the role of the government and private entities in producing knowledge to drive CDS?
- To what extent is the knowledge base a 'public good' that should be widely and freely available, and what are the implications of how this question is answered?

Table F: Recommended Actions for Advancement of Care-guiding Knowledge

	Near-term Tasks and Deliverables	**Who/How**
F.1	Prepare white papers that a. Review current and past initiatives to expand clinical knowledge via data mining and related techniques from EHRs. b. Describe a vision for how data within interoperable EHRs can be used to expand the health knowledge base. c. Address privacy issues identified above. d. Explore the implications of genomics knowledge and data for health knowledge discovery from interoperable EHRs. e. Recommend next steps in leveraging interoperable data in EHRs, RHIOs, etc. for generating new knowledge, informed by answers to key questions above.	Researchers (health services/outcomes/data mining, genomics), those involved in NHIN and RHIO development, AHRQ, others, privacy/HIPAA experts
	Mid-term Tasks and Deliverables	**Who/How**
F.2	Develop a consensus statement on the role of government and private entities in producing and managing knowledge to support CDS.	Government knowledge producers (e.g., AHRQ, CDC, FDA, etc), private knowledge producers (e.g., medical societies, EBM collaboratives such as Cochrane, CDS vendors), knowledge users
F.3	Pilot initiatives to demonstrate the viability and value of scalable approaches to generating and enhancing clinical knowledge from the	Researchers (health services/outcomes/data

	data in interoperable EHRs.	mining, genomics), those involved in NHIN and RHIO development, AHRQ, others, privacy/HIPAA experts
	Longer-term Tasks and Deliverables	**Who/How**
F.4	Assess need for ongoing maintenance and governance structures	CDS Roadmap Execution Steering Group, with input from pertinent stakeholders as outlined above
F.5	Identify a privacy entity to define and monitor appropriate uses for data	Legal/privacy experts, consumer advocates. Consider some type of commission; leverage related work by ONC via its privacy/security –related contracts

VI. Critical Path for CDS Activities

The goal of this Critical Path for CDS Activities is to move the U.S. toward enhanced health and health care quality (i.e., safety, efficiency, effectiveness, timeliness, patient-centeredness, and cost-effectiveness) through widespread use of robust CDS capabilities by consumers, patients, and health professionals. The immediate objective of the Critical Path is to set the stage for widespread use of next generation CDS capabilities by increasing successful use of currently available CDS interventions and demonstrating the feasibility, scalability, and value of addressing the CDS strategic objectives as described in Section II. The Critical Path tasks represent a subset of the comprehensive work plan (Section V) that can be most readily implemented and produce valuable results in the near term, and that will provide the necessary foundation for subsequent collaborations and investments needed to further build out national CDS capabilities.

This incremental approach to the addressing the comprehensive work plan is considered most practical, because no public or private entity currently has the mission, resources, and strategic plan necessary to assume responsibility for the comprehensive work plan. Key foundational elements that do not currently exist but that will be provided by the critical path tasks include: an ongoing forum for dialogue among the many CDS stakeholders, and input from those stakeholders into national initiatives for which CDS plays a critical role; consensus on the most important targets to address with CDS; and demonstration projects for successful deployment of CDS to address those targets in a manner that can be scaled nation-wide.

The Critical Path Tasks include:

1. Create a focal point for CDS in the form of a Roadmap Execution Steering Group (RESG) that will stimulate, coordinate, and guide CDS efforts outlined in this Critical Path and Roadmap. The RESG mission and structure should address the need for developing and maintaining an ongoing forum for dialogue, consensus, and action by CDS stakeholders.
2. Conduct discussions with specific organizations and initiatives with a role in promoting health care quality (e.g., AHIC, CCHIT, JCAHO, NQF, high profile pay for performance programs) on how CDS can advance their objectives and how such support can, in turn, facilitate execution of the tasks outlined in the Roadmap.
3. Promote dissemination and application of best CDS implementation practices through development and promotion of CDS implementation guides and lessons learned from successful sites as a means of increasing use of currently available CDS interventions.
4. Develop specifications and find funding for a set of coordinated, collaborative projects aimed at demonstrating the feasibility, scalability, and value of a robust approach to CDS using a focused, top priority target. For example, pilot initiatives could include using specific, standardized CDS interventions and integration strategies, and best practice implementation approaches, to increase medication safety or effective management of high-impact clinical conditions such as diabetes or congestive heart failure. (See Strawman Proposal).
5. Implement at least one of these scalable, outcome-enhancing CDS demonstration projects.
6. Analyze and generalize lessons learned from demonstration projects.

7. Address initial legal, regulatory, and financial issues that impact broader dissemination of CDS
8. Identify next steps for broader CDS development and implementation as an outgrowth of the activities above.

A proposed timeline for these tasks is presented in Table 2.

Table 2: Proposed Timeline for CDS Critical Path

June-December 2006 Release Roadmap Obtain seed money for and establish RESG Create forum for CDS stakeholders and promote collaborations with and input to quality improvement and health information technology initiatives (ongoing) Promote best practices for current CDS interventions (ongoing) Obtain funding to plan scalable outcome enhancing CDS demonstration projects Establish work groups that will provide input to specifications for demonstration projects
January – December 2007 Develop specifications for demonstration projects Obtain funding for demonstration projects Clarify and address legal, financial, and policy issues (ongoing)
January – December 2008 Implement demonstration projects Analyze, generalize, and communicate results of demonstration projects (late 2008 and ongoing)
January – June 2009 Develop plan to extend CDS model to other target areas (perhaps as a new round of demonstration projects)

Discussion of Tasks

Constitute, charge and fund a Roadmap Execution Steering Group

If developed as envisioned, some form of CDS could impact virtually every health care decision in the future. Achieving high adoption and effective use of robust CDS capabilities is a highly complicated undertaking as it lies at the nexus of information technology, medical and health-related knowledge, clinical workflow, quality improvement, constrained resources, and the need to influence behaviors of individual patients and health care professionals. In short, CDS

presents a challenge of both enormity and complexity. Yet, it is a challenge that must be pursued if the U.S. health care system is to reach its goal of high quality, cost-effective care.

Today, organizations in both the public and private sectors are directly working on pieces of the CDS challenge or are pursuing activities that both support and are supported by CDS. No single entity, however, has responsibility for advancing CDS as a primary strategy for improving the health of the nation. Nor is there a formal mechanism that ensures effective communication, coordination, and synergy among those organizations and efforts that already are engaged in activities related to CDS. In light of this gap, the CDS Roadmap Development Steering Committee recommended that a new entity (i.e., the Roadmap Execution Steering Group or RESG) be formed or an existing entity assigned responsibility to initiate the tasks outlined in this Critical Path and to serve as a focal point for CDS activity.

The CDS Roadmap Development Steering Group identified two possible approaches to establishing the RESG. First, a federal agency within DHHS, or a number of stakeholder agencies acting in concert (e.g., AHRQ, NLM, ONC), can constitute, charge, and fund the RESG. Alternatively, a non-governmental organization that is immersed in the CDS arena could, with appropriate financial support, form the initial RESG from appropriate stakeholder groups and thought leaders. The American Medical Informatics Association has committed to form such an entity. Further details will be announced shortly after the release of this Roadmap.

The RESG must be structured to be representative of the wide range of stakeholders who have a role to play in developing, using, and funding CDS, while still maintaining a reasonable size that enables the RESG to make decisions in a timely manner. Thus, a critical task for the RESG will be to establish formal mechanisms for gathering input from the broad array of CDS stakeholders (i.e., a CDS Forum).

Identify and cultivate synergies with current efforts, such as AHIC, AHRQ, CCHIT, JCAHO, IOM, NQF and other quality consortia, vendor and provider organizations, and pay-for-performance initiatives.

CDS is integral to and dependent on a variety of process and performance improvement activities within the health sector. To maximize impact, it is essential that new activities aimed at advancing CDS be initiated within the context of these efforts. This can be accomplished in part through the RESG and its CDS forum and an accompanying communication mechanism that the RESG will need to establish. In addition, the RESG should explicitly identify opportunities within existing health information, health care delivery, and research initiatives where CDS priorities could be strengthened, where CDS may provide specific value to projects already underway, and where linkages between these existing activities and new CDS activities driven by the RESG would be mutually beneficial. For example, federally funded health information technology (HIT) demonstration projects could be structured to include deploying and evaluating CDS interventions in a manner that advances execution of this Roadmap while addressing related demonstration project requirements.

Pertinent initiatives include, but are not limited to:

- AHIC: Fully accomplishing the objectives of the breakthroughs will require application of CDS; CDS-related activities outlined in this Roadmap can be accelerated by leveraging energy/momentum/attention generated by AHIC. (See Appendix C).
- AHRQ: AHRQ has a deep commitment to advancing the quality of care through its funding activities and its own thought leadership. It has consistently supported advancement of health care information technology and clinical decision support, and supported the predecessor work to this Roadmap (Teich et al., 2005).
- CCHIT: CDS functionality is an important component of HIT functionality that CCHIT is certifying, and that process can benefit from broad-based, well informed, coordinated input into CDS-related certification requirements. Because CCHIT is a high-profile focal point for multiple stakeholders in HIT and CDS (CDS/CIS developers, implementers, payers, etc.), the CDS-related activities in the Roadmap could potentially leverage some of that attention and effort.
- JCAHO: CDS is an important tool for addressing the increasing care safety and quality requirements of health care organization accreditation.
- Pay-for-performance programs, both private and public: CDS interventions provide a powerful toolkit for the care process and decision making changes needed to address the care improvements targeted by these programs.
- The IOM Roundtable on Evidence-based Medicine brings together key stakeholders from multiple sectors to consider ways that evidence can be better developed and applied to drive the effectiveness and efficiency of medical care in the U.S.

In addition, the RESG can leverage current momentum through visibility and project advocacy and build ongoing relationships with a nucleus of other key groups, such as Bridges to Excellence, Doctors' Office Quality-Information Technology Program (DOQ-IT), eHealth Initiative, Electronic Health Records Vendor Association (EHRVA), Healthcare Information and Management Systems Society (HIMSS), Institute for Healthcare Improvement, National Library of Medicine (NLM), National Quality Forum (NQF), provider organizations such as the American College of Physicians and American Academy of Family Physicians, and others. The CDS Forum can help build a shared CDS vision and accelerate CDS-enabled progress in health and health care delivery with broader audiences (e.g., providers, HIT vendors, knowledge producers and related organizations, payers, policymakers, standards development organizations, related public and private programs).

Promote best CDS practices through implementation guides, starter sets, and other means

There are considerable benefits to be gained through the broader use of currently available CDS interventions. Sharing best practices is a basic yet important way for organizations to reduce the uncertainty in finding successful paths for CDS implementation and should be pursued systematically and aggressively. First steps toward this objective include disseminating currently available sources and encouraging certification of CDS functionality and CCHIT's ambulatory and emerging inpatient certification requirements (Osheroff et al., 2005; Kilbridge, Welebob and Classen, 2001; CCHIT, 2006). In addition, institutions that have a successful track record of CDS use could be studied to identify which specific CDS approaches have been most useful for accomplishing high-priority objectives so that these specific best practices can be disseminated widely. Further, developing CDS starter sets – rapid consensus on core knowledge and interventions for specific high-visibility targets, such as chronic disease management for a specific condition, could provide clarity and unity for vendors and clinicians, and could lead to short-term achievements that can bootstrap further CDS activities.

Prepare and implement projects to demonstrate scalable value from CDS for priority targets

As described in the straw-man proposal that follows, there is a need to demonstrate the feasibility, scalability, and value of a standardized approach to representing, disseminating and evaluating CDS as outlined in this Roadmap. The proposed projects are intended to demonstrate and test the critical components of a robust and scalable approach to CDS for a narrow but high-priority target area.

Address legal, financial, and policy issues

A critical element of the CDS infrastructure is the set of incentives that encourage and support the development and use of robust CDS capabilities. These incentives or lack thereof will be determined in large measure by accreditation requirements, reimbursement mechanisms, legal protections for use of CDS, other regulations and laws, and various policies that encourage individuals and organizations to develop and use CDS capabilities. Some of these enablers have been discussed in the report from the predecessor effort to this Roadmap (Teich et al., 2005). For example, clarification of the limitations established by the Health Information Portability and Accountability Act (HIPAA) on using patient data for research would benefit researchers who generate the new knowledge that will be part of the CDS cycle. In addition, individuals whose work becomes incorporated into CDS algorithms should be recognized and rewarded by their organizations. Perhaps the most important need going forward is to develop a business case for each of the stakeholders who have a role to play in paying for CDS systems, including health care organizations, physician practices, and insurers. A key task is to identify initial issues for which solutions are feasible and valuable, and to review and facilitate existing and new efforts to realize such solutions.

Analyze, generalize, and communicate results of projects and use these results to develop a plan to broaden CDS to other target areas

The lessons learned and the value demonstrated from the projects outlined above should help clarify needed CDS enablers, refinements to the CDS infrastructure, and next steps for broadening the successful application of CDS to improve targeted outcomes. That is, they should help components of the CDS process become a regular, widespread part of everyday health and health care information management so that the vision of widespread, high-value CDS can be fully realized. The results of these demonstration projects should also provide guidance to CDS system developers and organizations implementing CDS. The foundation established by these initial efforts focused on demonstrating short-term value can then be built upon to more fully address the strategy outlined in the comprehensive work plan.

Straw Man Proposal for Demonstration of Scalable, Outcome-enhancing CDS

CDS has been shown to improve patient care processes and outcomes in a small set of institutions where it has been implemented and studied (Chaudry et al., 2006). The goal of this initiative is to demonstrate the feasibility of implementing CDS ***outside*** of benchmark organizations, in a systematic manner that can drive predictable improvements in health outcomes ***and*** be readily deployed in a variety of health care settings.

The innovations to be demonstrated and tested address the three pillars of a national approach to CDS that generates optimal outcomes (see Figure 2, Section II):

- providing the best available knowledge to a wide range of clinical applications and users
- improving adoption and effective use of CDS
- driving continuous improvements that yield more effective interventions and better, more useful knowledge.

The target scenario for the project applies CDS to improve safe and effective medication use and/or enhance management and outcomes for high-impact chronic diseases such as congestive heart failure or diabetes.

Specific deliverables from the pilot initiatives will include the following prototypes, models, and activities:

1. standard, highly practical formats for representing relevant medical knowledge, developed with CDS application in mind;
2. standard formats for general types of CDS interventions to convey this knowledge that can be readily incorporated into a variety of clinical information systems;
3. a knowledge service that collects, organizes, and makes available validated knowledge and specific interventions related to the target conditions in standard format[10];
4. proof of concept implementation of the above standards and services in multiple health care settings and in a variety of clinical information systems;
5. an organized collection of best practices for deploying CDS interventions reliably and successfully to improve outcomes in the targeted areas;
6. measurement and assessment of the usage of the above interventions, and an evaluation of their impact on patient care processes and outcomes, specifically on safety, efficiency, cost, and quality of care.
7. documentation of issues critical to successfully generalizing the lessons learned from these pilot initiatives to broader deployment of CDS (e.g., to support other conditions, other goals, other situations) and recommendations for successful scaling of benefits.

[10] A variety of models for single and multiple knowledge services have been discussed during the development of the Roadmap, and will be considered further during the execution phase.

These pilot efforts will bring together representatives from a variety of stakeholder organizations of the following classes (the specific organizations mentioned are examples for illustration purposes):

- pioneering institutions that have demonstrated improved outcomes from CDS
- institutions that have a basic health information infrastructure in place but have not yet implemented the CDS interventions that will be the focus of this project (i.e., potential pilot implementation sites)
- clinical information system and clinical decision support suppliers (who will help provide the CDS content and infrastructure for delivering it)
- representatives from relevant agencies whose work supports CDS advancement or whose work is supported by CDS (e.g., AHIC workgroups, JCAHO, CCHIT, NQF, pay for performance initiatives)
- organizations that might help to fund key elements of the project (e.g., AHRQ, NLM, ONC, CMS, other payers, RWJ Foundation)
- standards organizations that will be responsible for helping develop, maintain, and disseminate standards resulting from these pilots (e,g., HL7)
- organizations representing those who will be recipients of the CDS interventions (e.g., AHA, AHIP, ACP, ACS)
- other key stakeholders with important contributions (e.g., ISMP, IOM, chronic care model developers).

An initial core group of key stakeholders, subsequently expanded to a broader more fully representative group as project resources allow, will begin to refine the specifications of these demonstration initiatives and identify potential test sites.

The Roadmap Execution Steering Group (RESG) will oversee the planning phase of this project which will include convening key stakeholders, selecting target condition(s), refining project specifications, communicating with potential funders, and identifying potential test sites. Upon the availability of seed funding, the RESG will begin assembling key stakeholders in mid-2006, work to establish collaborations and synergies, and seek additional planning resources by late 2006. The goal is to secure project funding in 2007 and begin pilot project implementation in 2008.

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Appendix A
Definitions

Some terms used in this document are new terms, while others are often interpreted variably in different contexts. We define a few specific terms here as we mean them in this report.

Clinical Decision Support (CDS): Providing clinicians, patients or individuals with knowledge and person-specific or population information, intelligently filtered or presented at appropriate times, to foster better health processes, better individual patient care, and better population health. CDS interventions include alerts, reminders, and order sets, as well as other techniques for knowledge delivery including reference information and education (delivered with or without context sensitivity), health/clinical protocol and workflow orchestration support, display of context-relevant data, topic-oriented documentation forms, and others. Much of our discussion of clinical decision support here centers on its use within electronic health records and other computer-facilitated processes; however, the concept also applies to non-computerized knowledge delivery, such as paper mailings and brochures.

Clinical Knowledge: A generally applicable fact (or set of facts), best practice, guideline, logical rule, piece of reference information (such as a text article), or other element of information that is important to know for optimal data interpretation and decision-making regarding individual and population health and health care delivery. In a CDS system, a CDS **intervention** (see below) may use knowledge in at least two ways: as a logical rule to determine whether to deliver information, and as the information to be delivered itself. Example of clinical knowledge: "A mammogram should be ordered for any woman over 40 who has never had one." A characteristic of clinical knowledge is that it can be open to controversy and often evolves over time.

Clinical knowledge producers: Synonymous in this document with knowledge producers. Refers to entities that create and/or disseminate clinical knowledge. Examples include health care specialty societies, commercial clinical knowledge and CDS intervention vendors, health care organizations that share their clinical knowledge and CDS interventions with others, etc.

Clinical Information Systems: applications and hardware that manage patient care-related data. Application examples include Computerized Provider Order Entry (CPOE), Electronic Health Records (EHR), Personal Health Records (PHR), and departmental systems such as those that manage pharmacy, radiology and nursing information.

CDS implementers: health care delivery or other organizations that deploy CDS to end-users.

CDS Intervention: The delivery of one or more specific pieces of clinical knowledge or intelligently filtered data to an individual at a specific time and place to address a clinical objective. CDS interventions include the CDS content (i.e. clinical knowledge) and the logistics (such as software applications and workflow processes) by which it is delivered. Example of an intervention (using the example from the clinical knowledge definition): when a patient's electronic record is opened by a physician or nurse and positioned at an appropriate workflow

point, the system uses logic to determine if the patient is a woman over 40, a candidate for a mammogram, and overdue for the test. If these conditions are met, an alert notifies the end-user and provides a mechanism for placing the order if desired. Though computer-based interventions are generally more powerful and efficient, value has been demonstrated from paper-based CDS interventions such as manual flowsheets and flags on patient charts.

End-user: Synonymous in the document with CDS end-user. A clinician, health worker, patient, family member, or other person who directly uses CDS interventions in managing their own health or delivering and managing health care for others.

Knowledge Producer: and individual or entity that produces and delivers clinical knowledge for use in CDS Interventions. Can include professional societies, health care organizations, commercial clinical knowledge vendors and others.

Knowledge service(s): One or more services that collect (actually or virtually) and organize CDS interventions and clinical knowledge, and then make them available so that appropriate knowledge users can search for, access, and incorporate such knowledge and interventions into their own clinical information systems and other processes.

Knowledge user: A person or entity that makes use of the clinical knowledge and CDS interventions, e.g., as available in a knowledge service. A knowledge user may be a CDS end-user (see above), a researcher, a health care organization seeking to provide CDS interventions to its end-users (i.e. CDS implementer), or an information systems vendor/developer who wishes to make the knowledge available to end-users of its systems.

Appendix B
Examples of CDS Interventions

Below are screenshots of several different types of CDS interventions, to help provide the reader with concrete examples of how these interventions might appear to users.

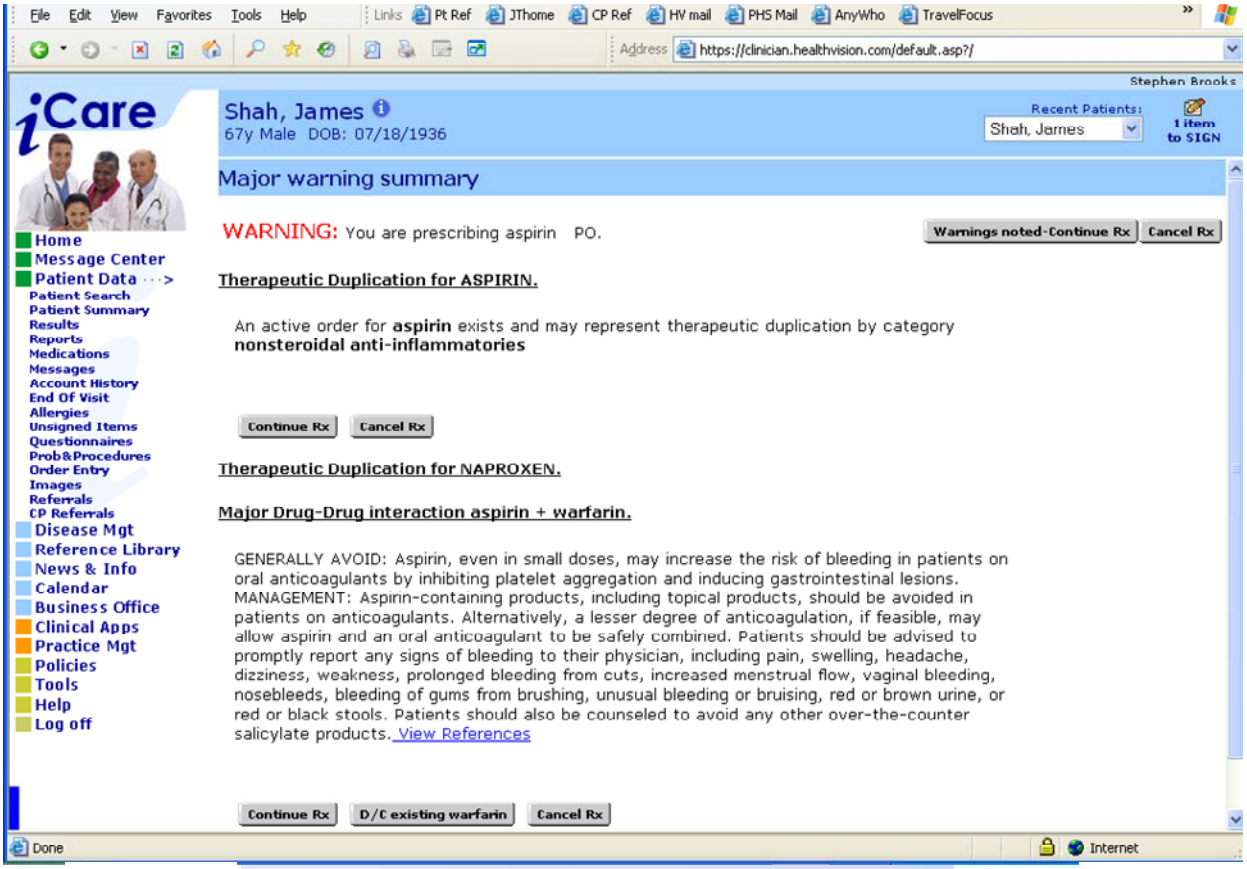


Figure 1 - Drug-drug interaction warning, in an e-prescribing system. The physician has prescribed aspirin, which interacts with warfarin, a drug the patient is already on. The system is warning the physician of this interaction, providing additional information necessary for the physician to make a decision, and allowing the physician to accept or reject the suggestion by pressing buttons. (Source: Healthvision, Inc.)

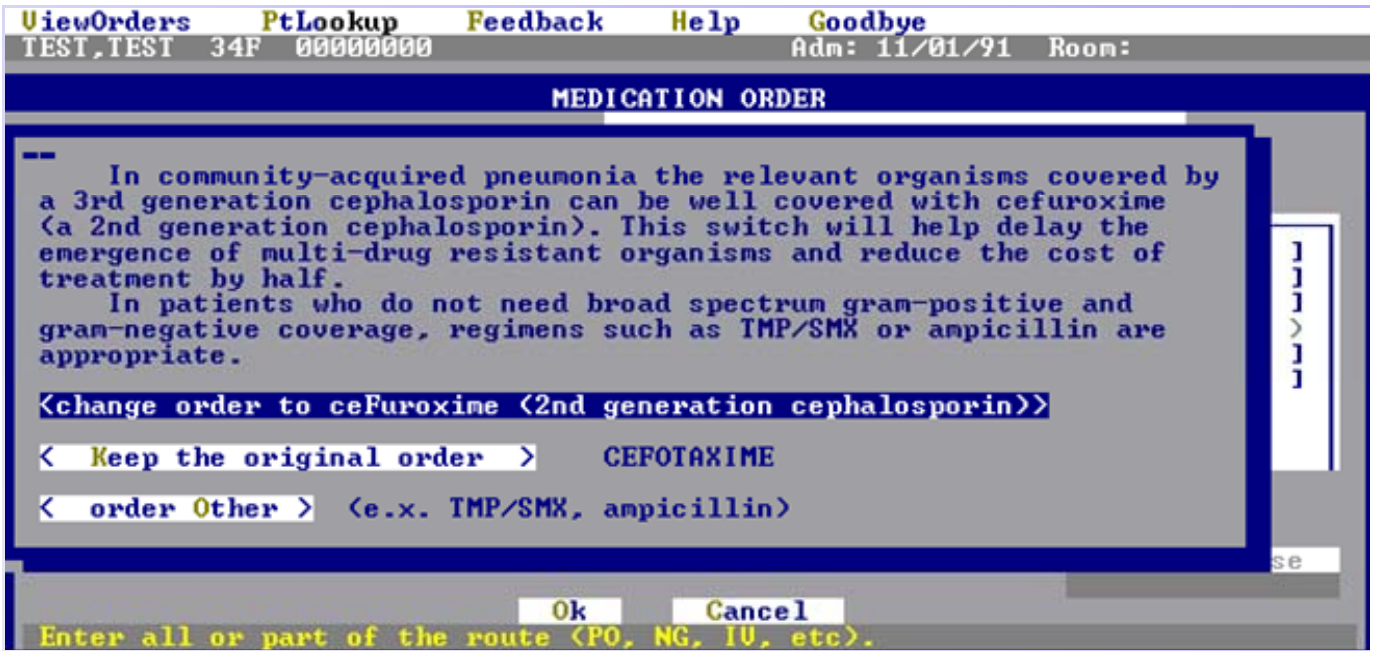


Figure 2 - A drug substitution warning in an inpatient computerized provider order entry (CPOE) system. The physician has ordered cefotaxime, an antibiotic. The system has determined that, given the patient's diagnosis of community-acquired pneumonia, the antibiotic cefuroxime might be a better choice. Again, the intervention provides additional information and allows the physician to make the final choice. (Source: Brigham and Women's Hospital)

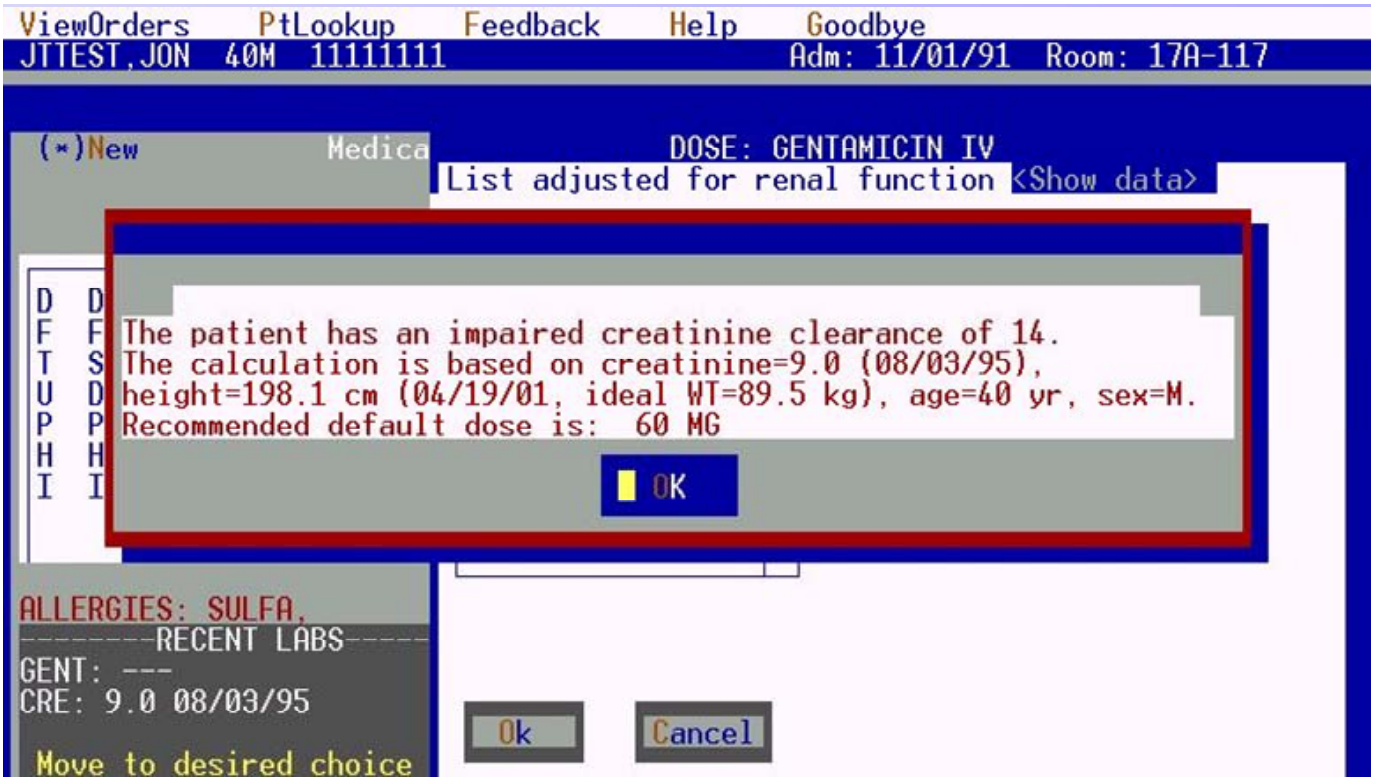


Figure 3 - Renal dose adjustment, in a CPOE system. The physician is ordering the drug gentamicin. Because this patient has kidney problems (as indicated by a low creatinine clearance), the normal dose of this antibiotic would be too high and could injure him, so CDS integrated into the CPOE system recommends a lower dose. (Source: Brigham and Women's Hospital)

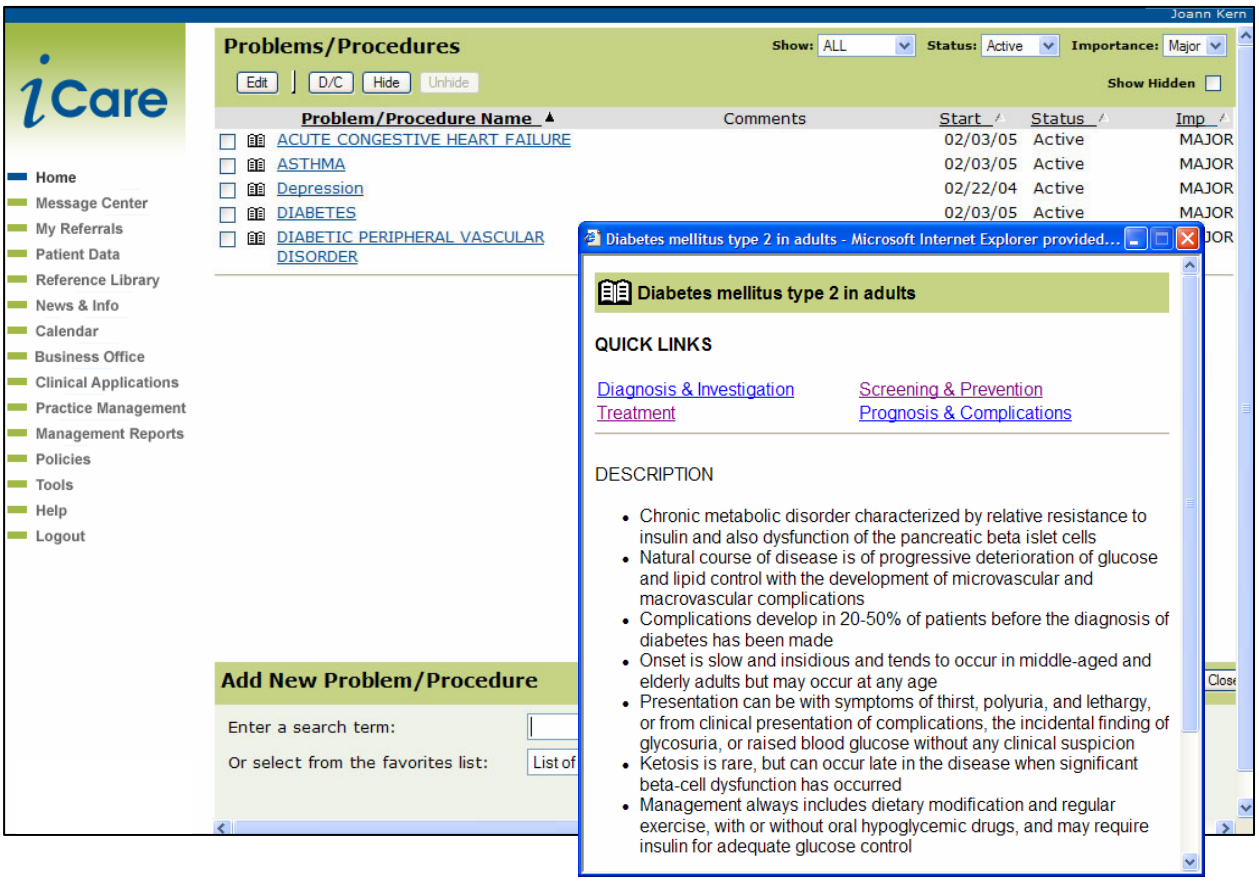


Figure 4 - An "infobutton" in an electronic health record. Infobuttons provide immediate access to frequently-needed information for the current clinical context, rather than making the physician search for and find the subject in a separate reference. Here, the physician is modifying the patient's problem list, and clicks the book icon to answer frequent clinical questions about the patient's diabetic condition. See the next figure. (Source: Healthvision, Inc.; Elsevier, Inc.)

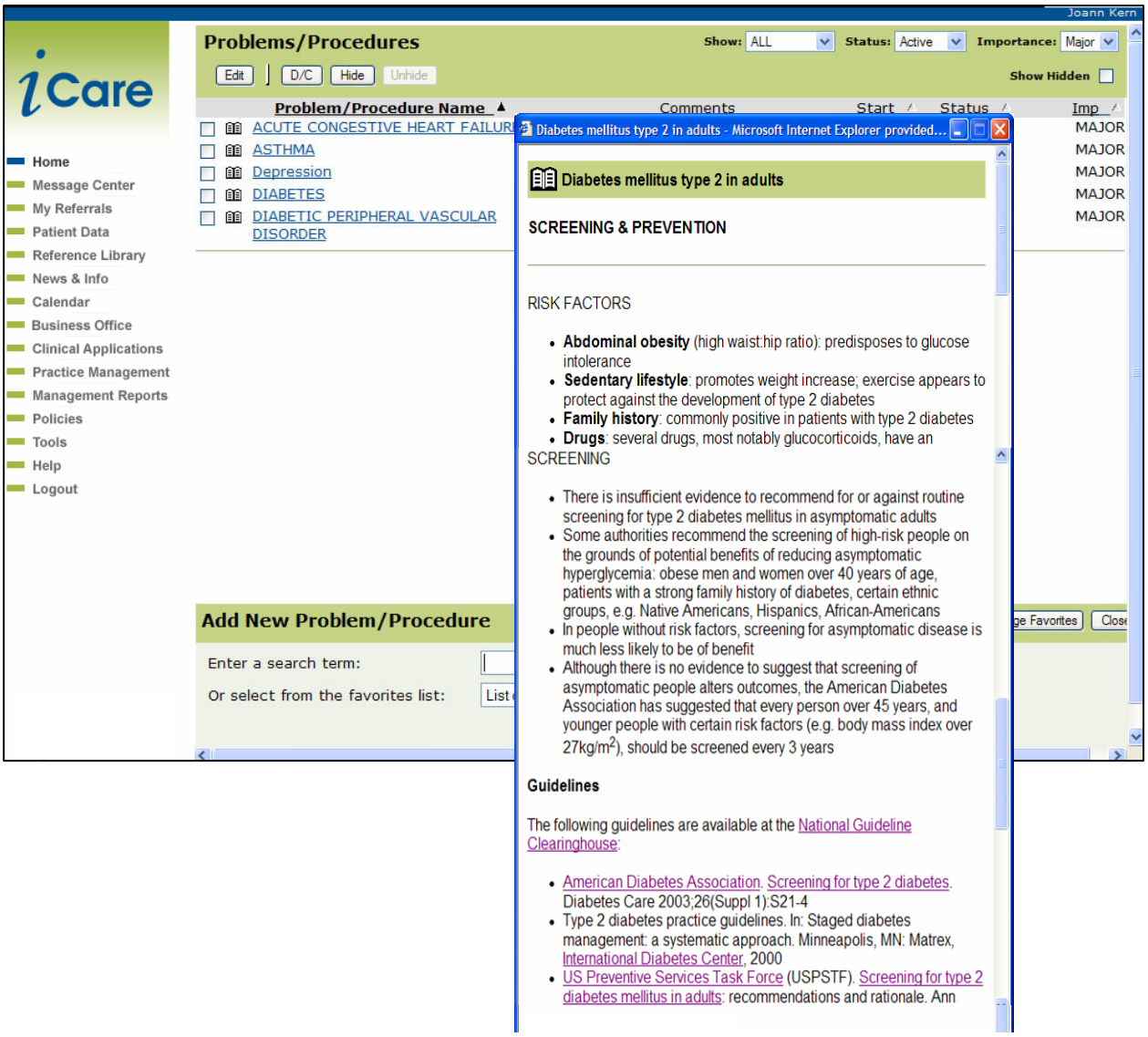
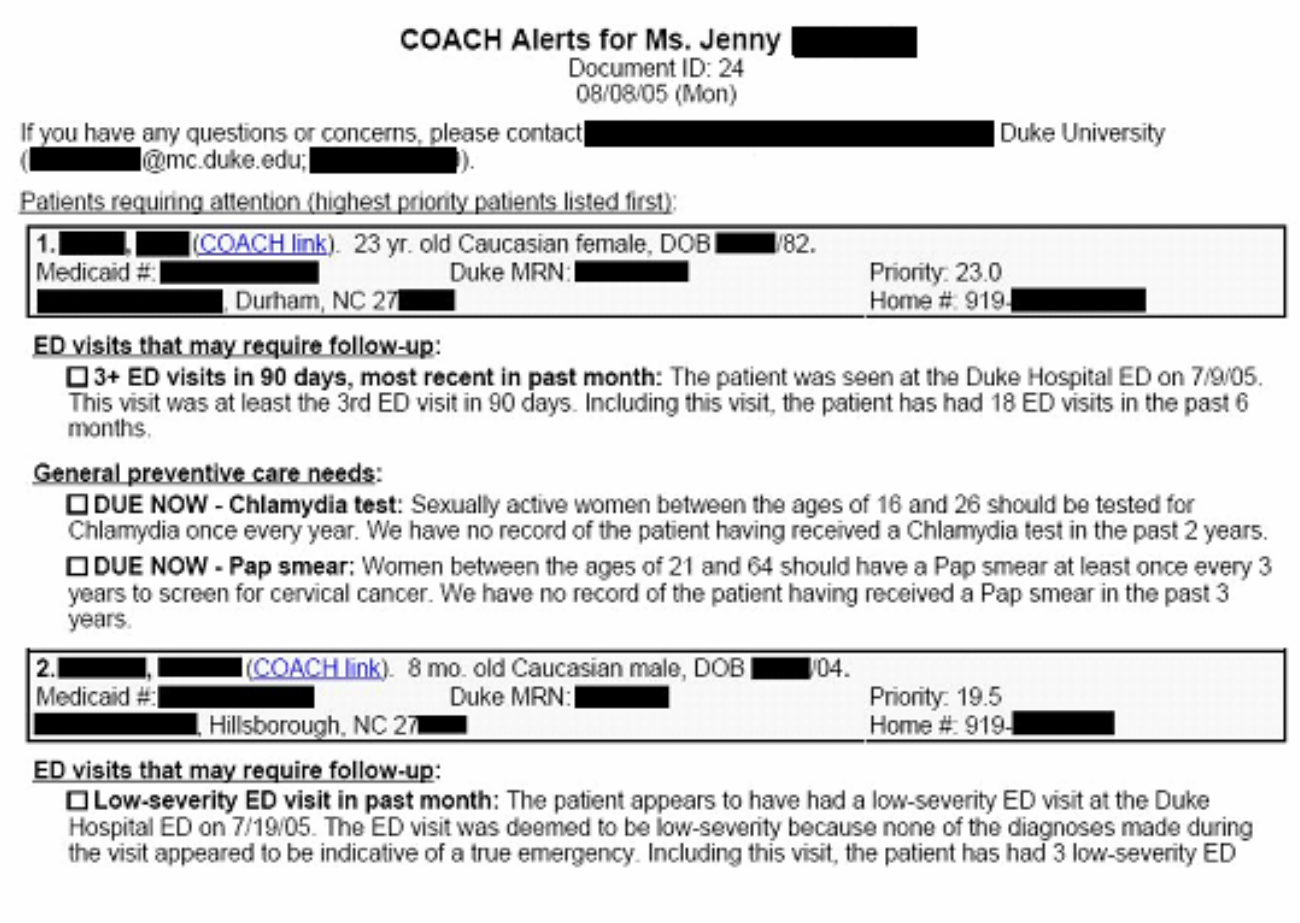


Figure 5 - Screening and prevention guidelines for diabetes mellitus type 2 are displayed by clicking a link on the infobutton result window in the previous figure. (Source: Healthvision, Inc.; Elsevier, Inc.)



COACH Alerts for Ms. Jenny [redacted]
Document ID: 24
08/08/05 (Mon)

If you have any questions or concerns, please contact [redacted] Duke University ([redacted]@mc.duke.edu; [redacted]).

Patients requiring attention (highest priority patients listed first):

1. [redacted], [redacted] (COACH link). 23 yr. old Caucasian female, DOB [redacted]/82.
Medicaid #: [redacted] Duke MRN: [redacted] Priority: 23.0
[redacted], Durham, NC 27[redacted] Home #: 919-[redacted]

ED visits that may require follow-up:

☐ **3+ ED visits in 90 days, most recent in past month:** The patient was seen at the Duke Hospital ED on 7/9/05. This visit was at least the 3rd ED visit in 90 days. Including this visit, the patient has had 18 ED visits in the past 6 months.

General preventive care needs:

☐ **DUE NOW - Chlamydia test:** Sexually active women between the ages of 16 and 26 should be tested for Chlamydia once every year. We have no record of the patient having received a Chlamydia test in the past 2 years.

☐ **DUE NOW - Pap smear:** Women between the ages of 21 and 64 should have a Pap smear at least once every 3 years to screen for cervical cancer. We have no record of the patient having received a Pap smear in the past 3 years.

2. [redacted], [redacted] (COACH link). 8 mo. old Caucasian male, DOB [redacted]/04.
Medicaid #: [redacted] Duke MRN: [redacted] Priority: 19.5
[redacted], Hillsborough, NC 27[redacted] Home #: 919-[redacted]

ED visits that may require follow-up:

☐ **Low-severity ED visit in past month:** The patient appears to have had a low-severity ED visit at the Duke Hospital ED on 7/19/05. The ED visit was deemed to be low-severity because none of the diagnoses made during the visit appeared to be indicative of a true emergency. Including this visit, the patient has had 3 low-severity ED

Figure 6. Population Health Management Alert. A decision-support system periodically (daily, in this case) reviews a database containing data for of a population of Medicaid patients. The system sends out alerts to care managers regarding concerning events detected from the data using a Web service-based rules engine. In addition to the sentinel event, the system also detects other potential deficiencies in care for the index patient. Alerts are prioritized based on the severity of the trigger event and other care needs. (Source: Division of Clinical Informatics, Department of Community and Family Medicine, Duke University)

Appendix C
AHIC Workgroup Overview and Relevant CDS Functions

The American Health Information Community (AHIC) is a 17 member advisory board chartered under the Federal Advisory Committee Act. AHIC advises the Secretary of Health and Human Services on Health IT issues, and its members represent most of the major health care stakeholder communities. The work of the AHIC is organized around four "breakthroughs" – tangible and specific short term wins for health IT, and each breakthrough is stewarded by a workgroup. The four workgroups are:

Biosurveillance
The broad charge to the biosurveillance workgroup is to "make recommendations to the Community to implement the informational tools and business operation to support real-time nationwide public health event monitoring and rapid response management across public health and care delivery communities and other authorized government agencies." The specific charge is to "make recommendations to the Community so that within one year, essential ambulatory care and emergency department visit, utilization, and lab result data from electronically enabled health care delivery and public health systems can be transmitted in standardized and anonymized format to authorized public health agencies within 24 hours."

Relevant CDS functions for this short term charge include but are not limited to:
- facilitating data reporting that is properly formatted and coded to provide useful information at the regional and national scale
- interpreting data streams and providing interpretation, alerts and notifications of high-consequence, natural or man-made events requiring attention
- facilitating and verifying communication to relevant authorities when an event occurs

Consumer Empowerment
The broad charge to the consumer empowerment workgroup is to "make recommendations to the Community to gain wide spread adoption of a personal health record that is easy-to-use, portable, longitudinal, affordable, and consumer-centered." The specific charge is to "make recommendations to the Community so that within one year, a pre-populated, consumer-directed and secure electronic registration summary is available to targeted populations. Make additional recommendations to the Community so that within one year, a widely available pre-populated medication history linked to the registration summary is deployed."

Relevant CDS functions for this short term charge include:
- standardized formats for medication list and history to facilitate patient and clinician decision making and communication
- intelligent linkage between personal health records and clinical data, facilitating secure exchange and appropriate protection of medication data
- interpretation of data, supply of educational materials and transaction facilitation specific to the patient's conditions and concerns

- patient-directed information to help them understand what medications they are taking and their desirable and potential undesirable effects, why they are taking them and how to take and handle them appropriately; support for medication reconciliation on hospital admission, tools to support medication administration timing and reminders
- interpretation of medication history data to spot drug interactions and other hazards, gaps in treatment needed for the patient's conditions, poor patient adherence to regimen

Chronic Care

The broad charge to the chronic care workgroup is to "make recommendations to the Community to deploy widely available, secure technologies solutions for remote monitoring and assessment of patients and for communication between clinicians about patients." The specific charge is to "make recommendations to the Community so that within one year, widespread use of secure messaging, as appropriate, is fostered as a means of communication between clinicians and patients about care delivery."

Relevant CDS functions for this short term charge include:

- Standard messaging templates (e.g., covering common clinical query and response topics) to help optimize efficiency and effectiveness of communication.
- Linkages to supportive instructional and informational material that clinicians can use in responding to queries
- ability to identify, from a large set of patients, those whose data suggest that their chronic conditions are at a dangerous point, requiring extra intervention
- administrative guidance through the logistics of obtaining, financing, and following through with referrals and other collaborative care
- enhancement of secure messaging to include easy access to typical functions such as medication renewal, scheduling (including self-scheduling), group and course registration, and more

Electronic Health Record

The broad charge to the electronic health record workgroup is to "make recommendations to the Community on ways to achieve widespread adoption of certified EHRs, minimizing gaps in adoption among providers." The specific charge is to "make recommendations to the Community so that within one year, standardized, widely available and secure solutions for accessing current and historical laboratory results and interpretations is deployed for clinical care by authorized parties."

Relevant CDS functions for this charge include:

- enhancements to systems that provide laboratory and other data, so that it is much easier for the user to find important new data, interpret it, take necessary actions, and communicate information to patients.
- more efficient and usable provision of alerts, information, forms, reminders, and other elements of CDS that have been shown to be effective in improving safety and quality.

Appendix D
Preliminary Compilation of CDS-related Standards and Pointers to Federal HIT Programs

As a reference for the interested reader, and to help provide a foundation for follow-on tasks from this Roadmap, a preliminary compilation of pertinent CDS standards is presented below.

Sampling of Initiatives involving standardized medical knowledge formats

Arden Syntax	http://cslxinfmtcs.csmc.edu/hl7/arden/
Asbru	http://smi-web.stanford.edu/projects/asgaard/AsbruL.html
Australian Health Info Council	http://www.ahic.org.au/downloads/nedsrept.pdf
CPG-RA	http://www.cpg-ra.net/
DeGel	http://medinfo.ise.bgu.ac.il/medlab/ResearchProjects/RP_DeGeLhtm.htm
EON	http://smi-web.stanford.edu/projects/eon/
GASTON	http://www.medecs.nl/nl-NL/gaston.php (in Dutch)
GELLO	http://www.hl7.org/v3ballot/html/infrastructure/gello/GELLOWhitePaperV1.2.pdf
GEM	http://gem.med.yale.edu/default.htm
GLARE	http://www.univ-savoie.fr/Portail/Groupes/DoctoralSchoolChyTurin/posters/web/France_article.pdf
GLIF	http://www.glif.org/glif_main.html
GUIDE	http://www.labmedinfo.org/research/dsg/decision_support.htm
HGML	http://infolab.umdnj.edu/
HL7 Decision Support Service	http://hssp-dss.wikispaces.com/
Prestige	http://www.ehto.org/ht_projects/initial_project_description/prestige.html
PRODIGY	http://www.prodigy.nhs.uk/
PROforma	http://www.acl.icnet.uk/lab/proforma.html
Protégé	http://protege.stanford.edu/
SAGE	http://sageproject.net/
SEBASTIAN	http://www.openclinical.org/gmm_sebastian.html
Stepper	http://euromise.vse.cz/stepper-en/

Directory of federal HIT programs: www.hhs.gov/healthit/federalprojectlist.html

Description of ONC activities: www.hhs.gov/healthit/documents/ONCinitiatives.pdf

Appendix E
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Appendix F
Glossary of Acronyms

AAFP-American Academy of Family Physicians
AAP-American Academy of Pediatrics
ACMI-American College of Medical Informatics
ACP-American College of Physicians
ACQA-Ambulatory Care Quality Alliance
ACS-American College of Surgeons
ADE-Adverse drug event
AHA-American Hospital Association
AHIC-American Health Information Community
AHIMA-American Health Information Management Association
AHIP-America's Health Insurance Plans
AHRQ-Agency for Healthcare Research and Quality
AMA-American Medical Association
AMDIS-Association of Medical Directors of Information Systems
AMIA-American Medical Informatics Association
ANA-American Nurses Association
AQA-Ambulatory Quality Alliance
ASHP-American Society of Health System Pharmacists
CCHIT-Certification Commission for Healthcare Information Technology
CDC-Centers for Disease Control
CIS-Clinical Information Systems
CITL-Center for Information Technology Leadership
CMS-Centers for Medicare and Medicaid Services
CPOE-Computerized Provider Order Entry
DHHS-Department of Health and Human Services
DOA-Department of Agriculture
DOD-Department of Defense
DOQ-IT-Doctors' Office Quality-Information Technology Program
EBM-Evidence-based medicine
EHR-Electronic Health Record
EHRVA-Electronic Health Record Vendors' Association
EPC-Evidence-based Practice Center
FDA-Food and Drug Administration
HHS-Human & Health Services
HIMSS-Healthcare Information and Management Systems Society
HIPAA- Health Insurance Portability and Accountability Act
HIT-Health Information Technology

HITSP-Healthcare Information Technology Standards Panel
HQA-Hospital Quality Alliance
IHI-Institute for Healthcare Improvement
IOM-Institute of Medicine
IP-Intellectual property
ISMP-Institute for Safe Medication Practices
JCAHO-Joint Commission on Accreditation of Healthcare Organizations
MLA-Medical Library Association
NCQHC-National Committee on Quality Health Care
NHIN-National Health Information Network
NIH-National Institutes of Health
NIST-National Institute of Standards and Technology
NLM-National Library of Medicine
NQF-National Quality Forum
NRC-National Resource Center
ONC- Office of the National Coordinator for Health Information Technology
PHR-Personal Health Record
QIO-Quality Improvement Organization
RESG-Roadmap Execution Steering Group
RHIO-Regional Health Information Organization
SDO-Standards development organization
VA-Veterans Administration